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Kelly Lake to Cheekye Substation Second 500 kV Transmission Line

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KELLY LAKE - CHEEKYE
500 kV TRANSMISSION LINE
TECHNICAL REPORT

Prepared by B. A. Hooper, A.Sc.T.

Approved by J. Coblenz, P. Eng.

Date 18 March 1991

TRANSMISSION ENGINEERING DIVISION
SYSTEM DEVELOPMENT GROUP

KELLY LAKE - CHEEKYE
500 kV TRANSMISSION LINE
TECHNICAL REPORT

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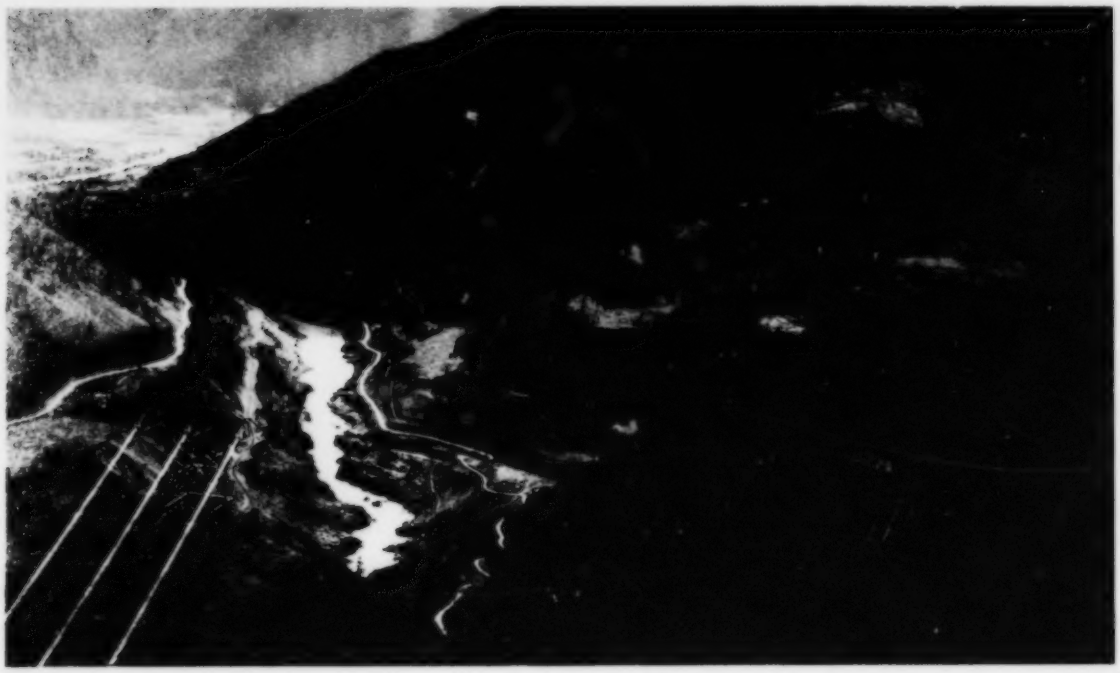

Photo 1 Existing 500 kV line, 5L42, north of Lillooet near the Bridge River Indian Reserve at the confluence of the Bridge and Fraser Rivers

1.0 SUMMARY

BC Hydro is proposing to construct a second 500 kV single circuit transmission line between Kelly Lake Substation near Clinton, and Cheekye Substation near Squamish B.C. The proposed completion date for this project is presently the fall of 1996.

Due to advantages of utilizing a tower which supports the conductors in an equilateral triangle or delta configuration (as compared to the conventional flat configuration), BC Hydro has undertaken to design and test a new family of towers for this project. The main advantages of this configuration are: reduced electromagnetic field (EMF) values; reduced clearing widths; reduced right-of-way; and higher power transfer capability.

The optimum size of conductor for this project is 926.7 MCM with an outside diameter of 29.16mm in a four conductor bundle per phase which is larger than the conductor (623.8 MCM and an outside diameter of 24.13mm) of the existing 500 kV lines from the Peace River project that are in the study area.

On a technical basis, the route recommended for this project is one that follows the existing 500 kV line, circuit 5L42 from Kelly Lake to Shalalth. From Shalalth, the recommended route then generally follows the established transmission line corridor through to Cheekye. A mixture of new and existing rights-of-way would be utilized throughout. Portions, if not all, of existing 230 kV transmission line, circuit 2L1, would be removed and sections of its right-of-way utilized for the new line. In other areas, an alignment adjacent to 5L42 is judged to be to be a more desirable location. In still other areas, a new separate right-of-way is considered to be the best route.

Recognizing that this recommended route traverses four native Indian reserves, alternate routes which by-pass these reserves have been identified and evaluated, and are also described in this report. Agreement with the various native bands on the use of the recommended route must be achieved by January 1992 or the alternate by-pass routes will have to be utilized for the project.

Preliminary survey control work is planned to begin in the fall of 1991.

Photo 2 Kelly Lake Substation with the two 500 kV transmission lines running south. The proposed line would be located on the east (or left hand) side of these lines

2.0 INTRODUCTION

2.1 PURPOSE AND SCOPE

The purpose of this report is to summarize (with the exception of the System Planning studies) all the technical studies undertaken by BC Hydro associated with the design and construction of a second 500 kV single circuit transmission line between Kelly Lake Substation near Clinton and Cheekye Substation near Squamish, B.C.

All technically feasible routes have been identified and evaluated. Technical factors that influence the cost, operating security, and maintenance of a transmission line are addressed in this report. These factors include:

- terrain/topography
- climatic exposure
- native vegetation and required right-of-way clearing
- access for both construction and maintenance
- route length

These routes have also been evaluated from an environmental perspective and the results of these environmental studies are addressed in a separate environmental report.

The costs associated with the construction of a 500 kV single circuit transmission line via all of the viable routes have been estimated for comparison purposes and are included in this report.

The report also briefly summarizes the evaluation and selection of the conductor chosen for use on this transmission line. The two tower configurationternatives being considered for use on this project are addressed and their relative advantages and disadvantages are discussed.

2.2 STUDY AREA

The area for this study extends south-westerly from Kelly Lake Substation, near Clinton, to Cheekye Substation, near Squamish.

This area encompasses approximately 7000 square kilometres primarily within the Pacific ranges of the Coast Mountains. The north-eastern end of the study area includes the Camelsfoot and Marble ranges of the Fraser Plateau. The study area in general is extremely rugged with mountains rising steeply to elevation greater than 2000 metres. Valleys are generally narrow, steep sided, and avalanche swept. The severe nature of the Coast Mountains and the physical constraints they impose on transmission line construction, generally confine feasible transmission line routes to valley bottoms and low sheltered passes.

The ranges of the Fraser Plateau are significantly less rugged and also are sheltered from the Pacific moisture that creates the icing and avalanche hazards of the Pacific ranges.

Numerous routes were initially considered for this project at the onset of this study in 1989. However, some of these were eliminated from the study at an early stage due to factors such as excessive length or to the physical difficulties that would be encountered in transmission line construction and maintenance. As these studies, together with the environmental studies and the public consultation program progressed, additional routes or route options were included in the study. These additions are referred to as the 1990 routes and route segments.

Photo 3 500 kV guyed flat configuration tower

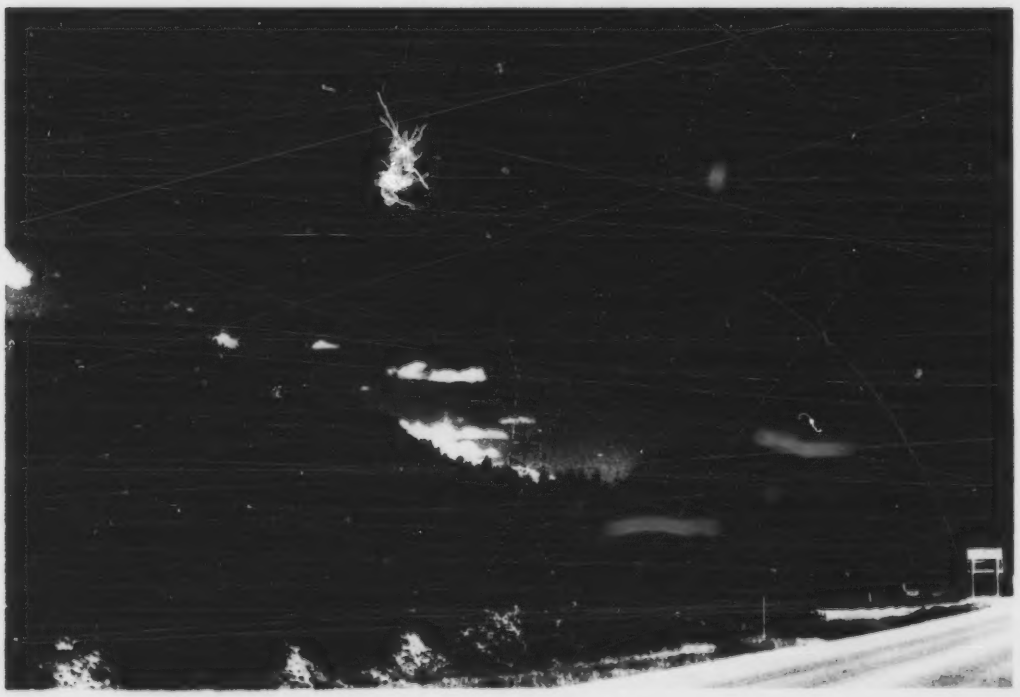

Photo 4 2L2 tower near Cheekye Substation

2.3 MAJOR TRANSMISSION LINES WITHIN THE STUDY AREA

There are presently four existing transmission lines within the study area between Kelly Lake Substation and the Bridge River Terminal at Shalalth, as follows:

- Circuit 5L41, a 500 kV line that generally follows the Fraser River to Ingledow Substation in the Lower Mainland. The line utilizes single circuit lattice steel towers with a bundle of 4 conductors on each of the three phases. Both guyed and self-supporting towers are used. Construction of this line was completed in 1969.

- Circuit 5L42, a 500 kV single circuit steel tower line, similar in design and appearance to circuit 5L41, that runs south to Cheekye Substation. This line is located adjacent to 5L41 south to Pavilion. Here it leaves 5L41, crosses the Fraser River and proceeds to Cheekye via Bridge River, Mission Ridge, Anderson Lake, D'Arcy, Pemberton, and Whistler. This line was completed in 1970 (See Photo 3).

- Circuits 2L90 and 2L91, two 230 kV single circuit woodpole lines that run from Kelly Lake to BC Hydro's Bridge River Terminal near Seton Lake. From approximately 6 km south of Kelly Lake substation, to Pavilion, these lines are located between circuits 5L41 and 5L42. From Pavilion, the lines generally follow Highway 12 through Fountain south to Lillooet. Continuing from Lillooet, the lines are located on the south shore of Seton Lake before crossing it and entering the Bridge River Terminal. These lines were completed in 1965.

South from the Bridge River Terminal at Shalalth, there are four existing transmission lines, as follows:

- Circuit 5L42, as described above

- Circuit 3L2, is a 360 kV line that runs from the Bridge River Terminal to Rosedale Substation via Pemberton, the Lillooet River, and Harrison Lake. The line utilizes single circuit lattice self-supporting steel towers which support a twin conductor bundle on each of the three phases. It was constructed in 1956.

- Circuit 2L2, is a 230 kV line that runs from the Bridge River Generating Station to Cheekye Substation via Pemberton, Whistler, and the Cheakamus River valley. The line also utilizes single circuit lattice self-supporting steel towers and a twin conductor bundle on each of the three phases. As such it is virtually indistinguishable from circuit 3L2. This line was designed and constructed to 360 kV standards but has always been energized at 230 kV. The line is connected to and supplies Pemberton Substation, and Rainbow substation at Whistler. It was completed in 1959 (See Photo 4).

- Circuit 2L1 is the line of prime interest for the Kelly Lake-Cheekye #2 project and this report. It is the other 230 kV line that presently connects the Bridge River Terminal with Cheekye Substation. Intermediate connections are also made with Pemberton substation, and Rainbow substation at Whistler. This line also utilizes single circuit steel lattice towers. The line is characterized by a single conductor on each of its three phases. The line was originally surveyed and designed in 1927 but was not constructed until 1948. This line is situated on a 60.96m (200 ft) right-of-way (See Photo 5).

Photo 5 230 kV line 2L1, beside Highway 99 south of Whistler

The access road that was built for the construction of these lines has been improved over time and portions eventually became Highway 99. This accounts for the close proximity of the lines to the highway in a number of areas.

2.4 PROJECT HISTORY

The following is a brief summary of the history of the Kelly Lake-Cheekye Project.

In 1979 BC Hydro initiated a study for a second 500 kV transmission line between Kelly Lake and Cheekye substations. At that time the project was to be a double circuit 500 kV line. BC Hydro undertook to complete a technical evaluation of route alternatives in concert with an environmental assessment carried out by Sigma Resource Consultants. These studies were consistent with the requirements of the Stage 1 regulatory process of the BC Environmental and Land Use Committee (ELUC).

These reports were published and distributed in mid 1981. They recommended a route that followed 5L42 from Kelly Lake Substation to Shalalth. From Shalalth to Cheekye, the recommended route generally made use of the right-of-way occupied by 2L1.

A public consultation process was undertaken in the fall of 1981.

In early 1982, as a result of declining electrical load growth, the project was revised from a double circuit to a single circuit 500 kV line.

Throughout 1982 work proceeded on further detailed technical and environmental studies of the proposed route.

In early 1983 the project was deferred due to a decline in the provincial electrical load growth.

Study on the project was reactivated in 1989 as a result of increased load growth in the Lower Mainland and on Vancouver Island.

2.5 2L1 RIGHT-OF-WAY

As noted in Section 2.3, circuit 2L1 is the 230 kV transmission line that runs from the Bridge River Terminal Station at Shalalth to Cheekye Substation. Circuit 2L1 is over 40 years old and has been deemed to be expendable to BC Hydro's transmission system. Therefore, portions between intermediate stations, if not all of it, can be removed. Substations served by 2L1 can now be supplied by connection to circuit 2L2. Previous studies recognized that after its towers were removed, portions of its right-of-way could be utilized for the new 500 kV transmission line. Although situated on a 61m right-of-way, which is sufficiently wide enough to accommodate a 500 kV line, the existing line is not in the centre of the right-of-way. Typically, the line alternates from being 42.67m (140 ft) from either the right or left hand right-of-way edge. The width of the clearing varies, but is generally in the order of 40m.

Photo 6 Looking north from D'Arcy along Anderson Lake

3.0 PROJECT DETAILS

3.1 PROJECT SCHEDULE

The presently proposed in-service date for this project is the fall of 1996. The schedule of the main design and construction activities required to achieve this completion date is shown below in Figure 3-1.

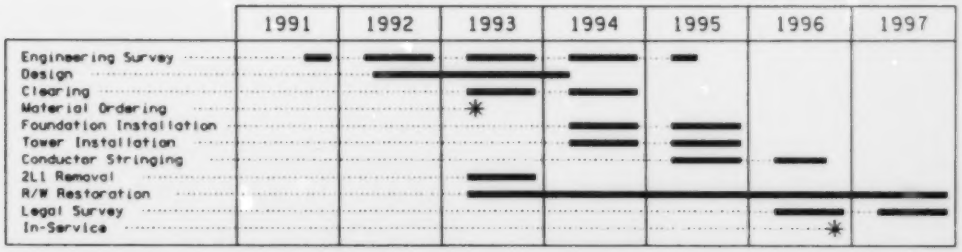

Figure 3-1 Proposed Project Schedule

This schedule is extremely tight with little opportunity for compression. Construction shut-downs as a result of closures due to forest fire hazard, prolonged periods of inclement weather, material and equipment shortages, or labour disputes could jeopardize accomplishing the 1996 completion.

This schedule indicates survey work commencing in the fall of 1991. This work is survey control preparatory to centreline survey which would be undertaken starting in early 1992. This work is essential in order to provide adequate time for the survey and design activities necessary to determine tower component quantities in sufficient time to order and receive tower and foundation steel for the 1994 construction season. The inability to commence survey work this fall could result in increased material and/or construction costs or increased risk in achieving the 1996 in-service date.

3.2 DESIGN DETAILS

3.2.1 TOWERS

The proposed transmission line project consists of a single circuit 500 kV steel tower transmission line between Kelly Lake and Cheekye substations. Two tower configurations are proposed for use on this project.

a) Flat (or Conventional). These are the 500 kV towers that were developed in the mid 1960s and 1970s for the Peace and Columbia River development transmission projects. It is the configuration used for 500 kV transmission lines throughout the BC Hydro system. It consists of a single circuit lattice steel tower supporting three electrical phases (conductors), in a flat or horizontal configuration. The suspension insulators are vertical strings. It includes both guyed and self-supporting towers. Specific tower heights would vary depending on topography and technical requirements. The guyed towers range in height from 27 metres to 40 metres. The self-supporting towers have a greater range at 27 metres to 50 metres. An average height for both types can be expected to be approximately 35 metres. Figure 3-2 illustrates typical outlines for both guyed and self-supporting flat configuration towers.

Photo 7 Alta Lake at Whistler. Note existing lines on west side of lake.

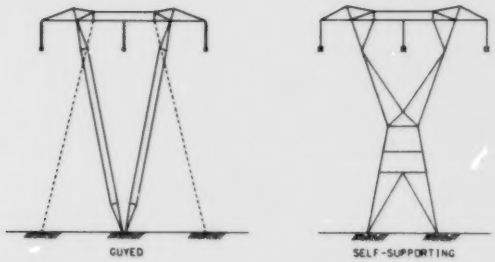

Figure 3-2 Flat (or Conventional) Configuration

b) Delta. This is a single circuit lattice steel tower with the three electrical phases (conductors), arranged in a delta or equilateral triangle configuration. Although new to BC Hydro, other electrical utilities in North America have used variations of this configuration. As with the flat configuration, there are both guyed and self-supporting types. The suspension insulators are double in a 'V' string configuration. The delta towers would typically be approximately 10m higher than a flat configuration tower. Therefore, there is a range of 35 metres to 47 metres for the guyed towers and 35 metres to 53 metres for the self-supporting towers. Similarly, a 45 metres average height can be anticipated for this tower configuration. Figure 3-3 illustrates typical outlines for this delta configuration tower.

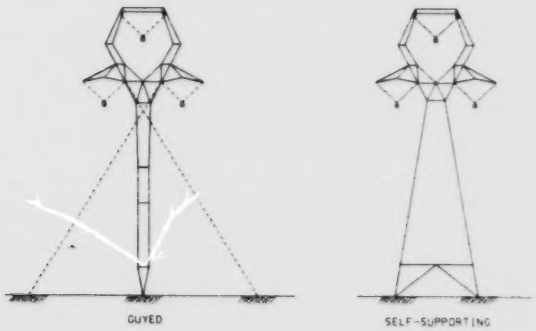

Figure 3-3 Delta Configuration

BC Hydro has undertaken to investigate the use of the delta configuration tower because it offers certain advantages over the conventional flat conductor configuration. These advantages include:

1) Reduced horizontal phase spacing, which results in;
   - reduced separation between circuits
   - reduced clearing widths
   - reduced right-of-way requirements
   - reduced alienation of land base

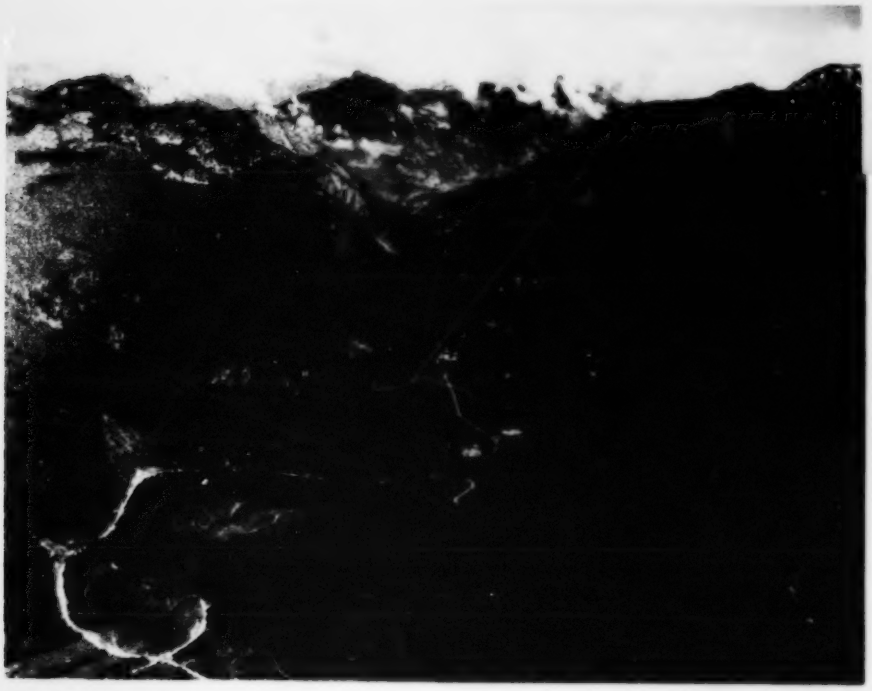

Photo 8 Birkenhead River Valley north of Pemberton, looking north towards Creekside Capacitor Station in centre of photo.

Photo 9 High alpine pass between Rutherford and Ryan Creeks.

2) Higher power transfer capability

3) Lower EMF (electromagnetic field) values. Compared to the conventional flat configuration, the reduction in the average value of the magnetic and electric fields occurring at the edge of the new narrower right-of-way is;
   - magnetic field reduced by 30%
   - electric field reduced by 20%

To utilize the delta configuration, a series or 'family' of towers has to be designed and tested. At present it is proposed to design a family of nine tower types. This would provide towers for most combinations of loading and site situations encountered on this line. The design and test of the delta tower family is not scheduled to be completed until 1992. The precise economics of utilizing the delta tower configuration cannot be completely established until this design is complete. Even then, construction and clearing costs can only be estimated. However, the investigations to date have indicated that the cost difference, if any, between the two configurations would be slight. The decision to use the delta tower is based therefore on this preliminary design information and the known afore mentioned advantages.

It is recognized that the delta tower would not be used exclusively throughout the length of the line. The high conductor ice and wind loadings resulting from the elevation and climatic exposure of some areas of the study area would warrant a heavier tower design than that proposed for the new delta towers. In these areas, an existing flat configuration design would be utilized. It is also acknowledged that in some areas, the additional height of the delta tower may be perceived as less desirable than the shorter flat configuration towers. In these areas, flat configuration towers would be utilized as well. These areas are identified and recommended in the environmental report.

For both of these configurations (flat and delta), guyed towers are used where terrain conditions permit and where routing is straight or has just small deflection angles (bends or corners in the line). It is anticipated that guyed towers would account for approximately 60% of the towers used on this project. Self-supporting towers would be used for larger deflection angles, at line terminations, in heavy snow areas, to suit certain terrain conditions (eg steep slopes or swamps), and generally where tower loadings warrant stronger heavier towers. Span lengths, or distance between towers, for both configurations would vary depending on terrain; however spans of 300-500m can be considered typical.

3.2.2 CONDUCTOR

Studies have been carried out to determine the optimum conductor size for use on this project. Generally these studies include such factors as:

- projected maintenance and operating costs
- projected anticipated present worth of electrical losses over the life of the transmission line (a function of the resistivity of the conductor and the cost of electrical energy)
- estimated present worth of the cost of the transmission line including material and construction costs
- projected electrical loads to be carried by the proposed transmission line.
- projected discount rates

The optimum conductor size is then found by comparing the total present worth resulting from the

Photo 10 Lillooet on the Fraser River. Note existing 230 kV lines 2L90 and 2L91 on slopes above town

Photo 11 Avalanche paths of the Ryan Creek segment.

transmission line construction, maintenance and operation costs, and the cost of electrical losses predicted over the life of the line. As the size of the conductor increases, the material and construction costs increase, but the cost of the electrical losses decreases.

This study resulted in the selection of a 469.5 mm² area (926.7 MCM), ACSR (aluminum conductor steel reinforced) conductor. This would be installed in a bundle of four on each of the three phases. This conductor has a core of 7 strands of steel surrounded by 45 strands of aluminium. It has an outside diameter of 29.16mm. This is larger than the conductors of the existing 500 kV lines in the study area which have an outside diameter of 24.13mm.

The conductor to ground clearance would vary depending upon the terrain, the ambient air temperature, and the electrical loading. However, the typical value for the minimum conductor to ground clearance (under maximum sag conditions) would be 9.6 metres. Higher values would be used where the line crosses roads, railways, pipelines, or other transmission or distribution lines. BC Hydro's designs for transmission lines, including ground clearances, meet or exceed Canadian Standards Association (CSA) recommendations.

3.2.3 TOWER AND CONDUCTOR FINISHES

Typically BC Hydro's transmission towers are made of galvanized steel. For a period of time after construction this galvanized finish has a shiny appearance. Similarly, the aluminium conductor has a reflective surface which also gives it a shiny look until the natural weathering process dulls it. During the public consultation program, it has been suggested that alternate finishes that are less reflective be employed for this line. Painting the transmission line towers is considered undesirable for a number of reasons. The initial cost of painting is expensive and maintaining it over the life of the line is also costly. It is also difficult to achieve a colour that is effective in all seasons and lighting conditions. Furthermore, in some situations such as in areas of frequent airplane and helicopter traffic, BC Hydro is required to mark or paint transmission lines to enhance their visibility for aviation safety. It would be counter productive to conceal the towers by painting them.

BC Hydro is however investigating the use of a 'non-specular' or dull weathered finish for its tower steel and conductor. These techniques exist but further investigation is necessary to establish the availability and cost for application on the Kelly Lake-Cheekye project. Preliminary indications are that this type of process would add approximately 10% to the material costs. It may be reasonable to use these dulled finishes in some of the more visually sensitive areas. Availability of these finishes, especially in small quantities, and the ability to identify and specify the necessary tower components for these areas, may be factors in the practicality of their use for this project.

3.2.4 RIGHT-OF-WAY REQUIREMENTS

Legal *right-of-way* requirements should not be confused with clearing width requirements. Right-of-way widths are determined based on guidelines recommended by the Canadian Standards Association (CSA) electrical code requirements. These include the physical geometry of the transmission line, in particular:

- horizontal conductor spacing, i.e. distance from centreline to the outside phase.
- conductor weight and size (this determines the degree to which the conductor swings under the wind and temperature conditions specified by CSA)

Photo 12 Cheekye Substation.

- conductor sag, determined by conductor tension and weight, and span length
- the physical geometry and conductor sag characteristics of adjacent transmission lines (if any) and the separation required between the lines.

For the recommended route (as well as all the possible alternatives), the requirements for additional right-of-way would vary from nil (where it utilizes existing right-of-way), to the acquisition of a full new right-of-way. Table 3-1 provides comparative examples of the varying typical minimum additional right-of-way requirements for flat and delta tower configurations.

	5L46 CONFIGURATION	
	Flat Configuration	Delta Configuration
Separate New R/W	64 m	50 m
Adjacent to Existing Line 5L42	43 m	35 m

Table 3-1 Typical Additional Right-of-Way Requirements

The standard offsets from adjacent lines and the subsequent required additional right-of-way will not be established until the final route has been established. However Figure 3-4 provides the detail of the additional typical right-of-way requirements for delta configuration adjacent to the flat configuration of existing 5L42.

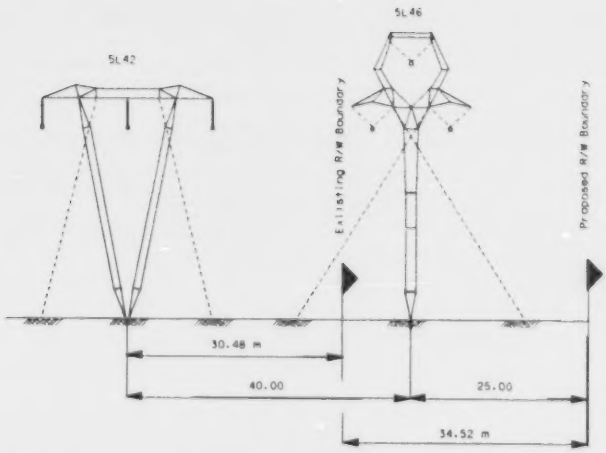

Figure 3-4 Typical Right-of-Way Requirements

Photo 13 Creekside Capacitor Station

Photo 14 Rainbow Pass looking north. Note potential location of line.

Non-standard separations and additional right-of-way requirements will occur along the transmission line route. Examples include locations at long spans where separation has to be increased to allow for greater conductor swing, or where terrain constraints do not permit the new line to be placed exactly parallel.

In some areas where there is judged to be a risk from such hazards as avalanches or earth slides, separation from adjacent lines would be increased. This would result in the necessary additional right-of-way being wider than that shown in Table 3-1.

Where the existing right-of-way of 2L1 would be used, generally the proposed line would be located in the centre of the 61 metre right-of-way. In some areas however, topographic constraints could necessitate positioning the new line such that some additional right-of-way adjacent to the existing right-of-way, would be required. Similarly, on the west side of Alta Lake, the existing 2L1 right-of-way is only 38 metres wide. Should the proposed line be located on this alignment, the existing right-of-way would have to be widened to 50 metres for delta towers or 64 metres for flat/conventional towers.

3.2.5 SUBSTATION REQUIREMENTS

The proposed line will connect to existing Kelly Lake and Cheekye substations. Some expansion of the station equipment to accommodate this new line will be necessary at both of these stations. The design of this station expansion is currently under review. However, at this time, it is believed that the required work will be contained within the existing property boundaries.

A requirement of this project is the introduction of a capacitor station somewhere near the mid-point of the line. As the technically recommended route is close to the existing Creekside Capacitor Station just north of Pemberton, then this site would be expanded to accommodate the additional equipment. This expansion would be within the existing property boundary (See Photo 13).

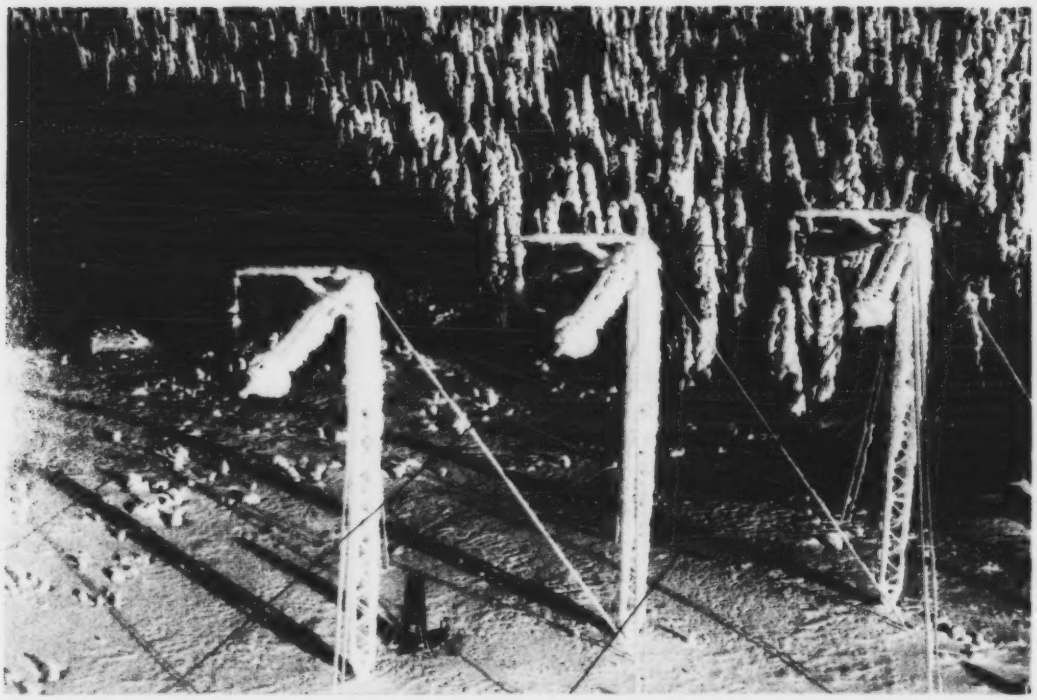

Photo 15 Existing 5L42 tower on Mission Ridge. Note heavy tower design and single bundle conductor to withstand high ice and wind loads.

4.0 SURVEY

An in-service date of the fall of 1996 for the Kelly Lake-Cheekye project requires that tower material quantities be determined by May of 1993. To increase the probability of achieving this date, it is necessary to initiate the survey control in the fall of 1991.

The survey control is the establishment of vertical and horizontal coordinates of points along the proposed route. This mathematically links these points along the centreline and enables the subsequent centreline survey to be underway simultaneously at a number of locations along the route. This provides a common, unvarying datum for the centreline survey data and facilitates the surveying of a centreline between the points along the centreline.

The procedure for this survey control work typically involves triangulation between these points on or near the transmission line centreline utilizing electronic measuring equipment. Line of sight is generally required to common prominent locations between the points on centreline. A survey tag or hub is installed at each of the control points along centreline. Little cutting of trees or vegetation is usually necessary. There is no cutting of centreline at this stage of the survey. In some cases, white cloth targets are installed for aerial identification purposes.

This control survey would be carried out over the entire proposed route plus any route alternatives still being considered. The work will also enable photogrammetric mapping to be produced which will assist in the evaluation of some of the more technically difficult and/or environmentally sensitive areas.

After the route has been confirmed, final centreline survey commences. This second stage involves the cutting of a narrow, 2-3 metre wide sight line along the proposed alignment and the taking of a profile along the centreline. Numbered survey tags or 'hubs' are installed at intervals along the line (usually 50-60 metres). Access to the line by the survey crews is by foot, road, or by helicopter.

The next stage in the survey of the line is the establishment and staking of individual tower sites. This is performed after the location, type and height of the towers have been determined using the centreline profile.

The legal survey of the right-of-way and the preparation of the legal survey plans usually follow the construction of the line.

Photo 16 Example of where conductors are above tree height and clearing is not required.

5.0 CONSTRUCTION PROCEDURES

5.1 ACCESS

Access for the transmission line construction will normally be by roads, the standards for which are dependent on the extent of the area served by a given road, environmental considerations, the nature of the equipment which must use the road, land ownership, and any on-going needs for line and right-of-way maintenance. Where ground access is deemed inappropriate or not possible due to potential environmental impact or physical constraints, access may include the use of helicopters.

A preliminary access assessment is being prepared for the proposed route and the main alternatives. This identifies any existing roads that may be used in the construction and maintenance of the new line. It also makes recommendations where the construction of new roads may be required.

Once centreline survey and tower layout are completed, a detailed access assessment will be prepared for the project. This will provide further detail on the location and standards of the roads to be used for clearing and construction. This access assessment will take into account:

- type and location of towers,
- construction methods,
- ownership of land, crown or private,
- presence of merchantable timber,
- environmental considerations.

On this project, it is intended that most of the main access road construction be developed to the greatest extent possible during the clearing and logging phase.

5.2 LOGGING AND CLEARING

The first major activity in the construction of the transmission line is the removal of tall growing vegetation which would interfere with the safe operation of the transmission line. The amount and width of clearing for the transmission line is determined by;

- ground slope
- horizontal conductor spacing
- conductor swing
- conductor height above ground
- tree height
- species and growth rates of the forest cover.
- line reliability requirements
- public safety

For example, in areas with short, slow growing trees, the clearing boundaries may be narrow enough to be inside the right-of-way boundary. In areas with tall timber and steep side slopes, the clearing boundary may be outside the right-of-way. In some areas where the conductor is well above the average tree height, particularly across gullies and streams, clearing is not required. (See Photo 16) In areas where clearing width is a concern, some thinning, trimming, and topping of trees in selected areas may also be carried out. Trees outside of the normal clearing that are taller than the predominate tree height are also individually removed if they pose a hazard to the transmission line. They are referred to as *Danger Trees*.

Timber that is economically recoverable would be harvested as merchantable timber. In most cases

Photo 17 Earth foundation installation.

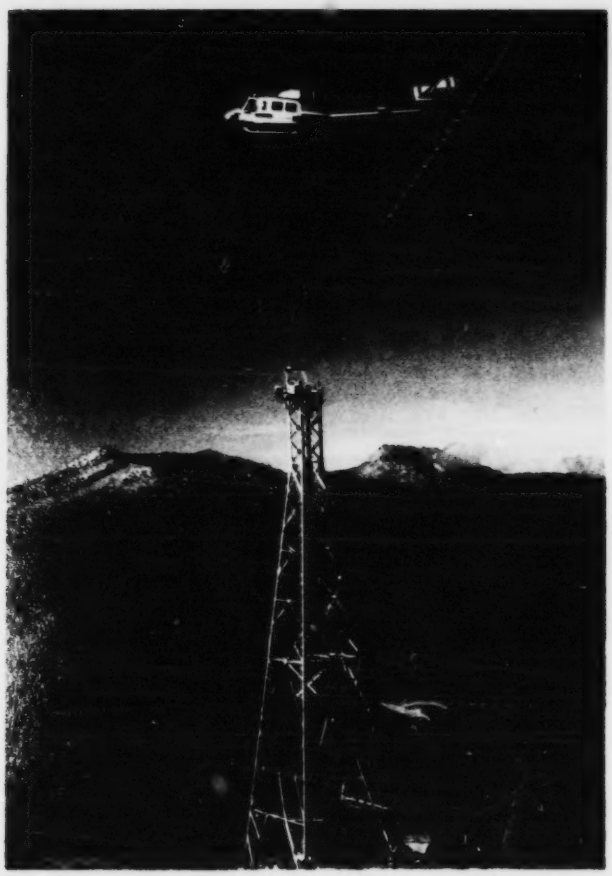

Photo 18 Tower erection using helicopter.

the timber is cruised, and on private land, appraised. Merchantable timber would be harvested under one of the following scenarios:

- BC Hydro's contractors would harvest Crown timber as part of the right-of-way clearing contract and depending on discussions with the Ministry of Forests and conditions of any Licences to Cut, either;
  (i) market it themselves, or
  (ii) deck it for sale by the of Ministry Forests

- Private landowners may elect to harvest their own timber.

- Private landowners who do not remove their own timber would have the timber harvested by BC Hydro's contractors and would either:
  (i) retain ownership and have the timber decked on their property for their use or disposal, or
  (ii) be compensated by BC Hydro with the timber removed by the contractor

It is the intent that all merchantable timber be harvested. Timber which is not merchantable because of size, grade, species, or location would be disposed of by a variety of methods depending primarily on terrain and access. In areas accessible to equipment, the waste wood and brush would be piled and burned. In areas limited to hand work, all waste wood under 15 cm and brush would usually be piled and burned and the larger stems would be cut and left to lie flat on the ground.

The clearing methods are specified by BC Hydro and would vary depending on terrain, slope stability, erosion potential, proximity to environmentally sensitive areas, and private landowner requirements. BC Hydro closely monitors the clearing operation to ensure that these specifications are carefully adhered to.

5.3 FOUNDATION INSTALLATION

After the right-of-way has been cleared and the towers sites staked, foundation installation begins. Depending on schedule, working conditions and the number of crews, foundation installation may begin simultaneously at various points along the line. Separate crews are generally used for access road construction, site preparation and for the different foundation types to be installed (earth foundations, guy anchors, rock footings, piles, etc).

After the site has been prepared, excavation in earth for grillage foundations/guy anchors is carried out by rubber tired or crawler equipped backhoes (See Photo 17). Crawler equipped tank drills, compressors and hand held rock drills are used for drilling rock anchors and for blasting shallow depth rock at grillage sites.

Components for grillage foundations are usually stored and assembled at temporary yards set up along the length of the line. The assembled grillages are then delivered to the site, positioned in the excavation, and the backfilled and the earth compacted around them.

Rock and concrete footings are constructed on site. Concrete for the footings can be mixed at portable batch plants set up along the route or purchased from local suppliers. Foundation materials, concrete, small equipment and construction crews can be transported to otherwise inaccessible sites by helicopter.

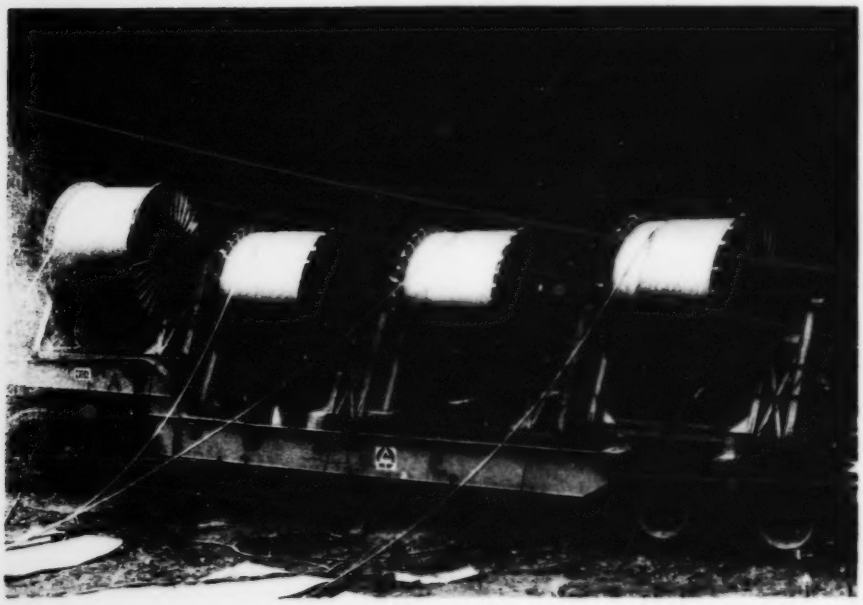

Photo 19 Flat deck truck carrying conductor reels.

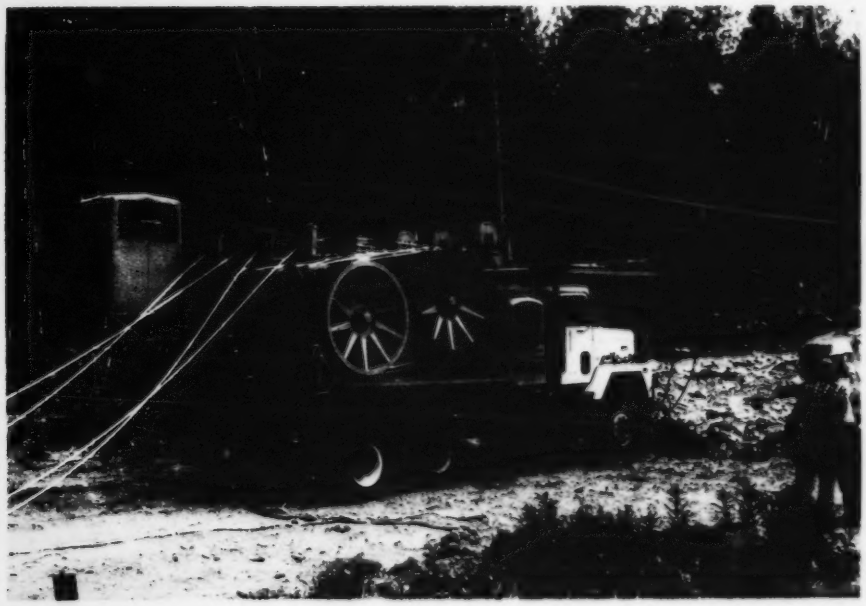

Photo 20 Equipment used for conductor installation.

5.4 TOWER ERECTION

The next major phase of transmission construction is tower assembly and erection. Depending on scheduling and other factors, this phase of the work may or may not be carried out by the same contractor who installed the foundations. Nonetheless the two operations are typically carried out separately.

Tower steel is delivered to temporary steel yards established along the route from where the steel is sorted and distributed to the tower sites by various means, the most common of which is crane equipped, flat-bed trucks.

Tower components are generally assembled on site by crews working ahead of the tower erection crews. The tower components are assembled utilizing 15 to 20 tonne cranes.

Tower erection is usually carried out by large truck-mounted hydraulic cranes which have capacities of 35 to 65 tonnes. Cranes of this size are cumbersome and thus sometimes require bulldozers to aid in maneuvering and for preparation of working areas.

Tower erection in physically difficult or environmentally sensitive line sections can be accomplished by helicopter but as with foundation installation has its difficulties, limitations, and higher costs (See Photo 18).

5.5 CONDUCTOR STRINGING

Conductor stringing, like foundation installation and tower erection, is usually done under a separate contract. This phase of construction is complex, involving stringing, sagging, clipping, and dead-ending the conductor.

Large specialized equipment such as line pullers and tensioners are required for the stringing operation. This equipment cannot be lifted by helicopter and requires good access; this equipment is only needed at intervals along the line (See Photos 19 and 20). The spacing of these "set-ups" is generally limited by the length and weight of conductor on each reel.

The conductor is pulled between the set-ups by first stringing a small diameter line through sheaves (or pulleys), on each tower. This operation is usually done by helicopter. This small line is then used to pull a steel pulling line which is attached to the conductor. The conductor in turn is pulled through using the steel line. The conductor is kept under tension to avoid damage by contact with the ground or obstructions.

After the conductor has been strung it is sagged to a specified tension and connected to the insulator assembly on the tower. Cranes, forklifts, specially equipped caterpillar tractors and all-terrain vehicles are used for handling material, hanging insulators assemblies and other stringing activities. Material yards are established at various intervals along the route.

Photo 21 Cavanagh Creek at the Fraser River.

Photo 22 Looking up Antoine Creek from the Bridge River.

6.0 ROUTE DESCRIPTIONS AND TECHNICAL ASSESSMENT

6.1 INTRODUCTION

For the purpose of identification in this report and the technical analysis herein, and to maintain compatibility with the environmental studies being carried out concurrently, all the routes have been broken down into route segments. These route segments and the delineating node points are shown on Drawing B1 contained in Appendix B of this report.

In addition to the routes initially identified for study in 1989, further routes and route segments evolved from the technical and environmental studies, and the public consultation program. For the purpose of this report, the description of all the routes has been separated into the original 1989 segments, and the additional 1990 segments.

All routes and route segments are shown on Drawing 5L46-T07-X5M, sheets 1-9 inclusive, included in Appendix B of this report. This Plan of Route Alternatives is at a scale of 1:50,000 and contains nine maps. A key plan of these nine maps is also included in Appendix B.

A brief description of each of the route segments and their pertinent features is given with reference to these maps in the following sub-sections.

6.2 ROUTE SEGMENTS (1989)

6.2.1 KELLY LAKE (A-B)

This short segment is the first section south out of Kelly Lake Substation. This segment contains existing 500 kV lines, circuits 5L41 and 5L42 (See Photo 2). Unused, uncleared, existing right-of-way on the east side of these lines would be used for the proposed line. Roads developed for the construction of the existing lines would provide much of the access necessary for the new line and only additional spur roads to tower sites may be required. No hazards are anticipated to be encountered in this section.

6.2.2 ANTOINE CREEK (B-U-X-V-G)

A line via this segment would leave the existing transmission line corridor and cross both the existing 500 kV lines and then the two 230 kV woodpole lines. The route then crosses the BC Railway and Kelly Creek and then descends via Cavanagh Creek to a crossing of the Fraser River (See Photo 21). There is some existing road access on both sides of the Fraser River. The stability of the slopes in Cavanagh Creek as well as on the banks of the Fraser River are a concern. These constantly eroding slopes could pose a hazard to the security of the line if extreme care in the location and construction of the line is not taken.

The span crossing the Fraser River would not be of an unusually long length. There is however, concern for aviation safety with the addition of another transmission line crossing of the Fraser River.

From the west side of the Fraser River, the route makes a gradual ascent of the Camelsfoot Range through some areas of logging. Access is available from existing logging roads in the area. The

Photo 23 The 5L42 crossing of the Fraser River at the Pavilion Indian Reserve.

descent of the southwest side of the Camelsfoot Range is via Antoine Creek. The creek valley has steep slopes and the line would have to be located on a series of high ridges. Preliminary investigation indicates that secure tower sites could be found. However further study is required to determine the span lengths and the resulting tower requirements. Access into the area is very limited and would be very difficult to develop (See Photo 22). After crossing the Bridge River valley immediately north of the Bridge River Indian Reserve, the route turns and runs south, ascending Mission Ridge. This is gradual and there is existing access from logging activity in the area. At Mission Ridge the line would intersect and parallel the existing 500 kV line, 5L42.

6.2.3 PAVILION (B-C-E-F)

The route in the first portion of this segment continues within the existing unoccupied right-of-way along the east side of circuits 5L41, 5L42, 2L90, and 2L91. The total right-of-way is approximately 210 metres in width through this area to Pavilion, which is sufficient for the proposed new 500 kV transmission line. The area is predominantly flat rangelands with good existing road access. At Pavilion, the proposed line would cross circuits 5L41, 2L90, and 2L91 (See Photo 23). The line would then cross the Fraser River parallel to circuit 5L42. The line would then continue to parallel 5L42 across the Camelsfoot Range, the Bridge River, and the Bridge River Indian Reserve (See Photo 1). A widening of the existing right-of-way would be required in this section. In this segment from Nodes E through F, several locations that would require special attention are encountered. Long spans, and areas of steep sidehill would require careful tower placement (See Photo 33). In some instances, such as immediately north of the Bridge River crossing, the proposed line would be adjacent but may not be parallel to the existing line. For most of this segment, existing roads from the construction of 5L42 would provide the necessary access for the new line.

6.2.4 MISSION RIDGE (F-G)

From the south side of the Bridge River crossing, the route ascends the north slope of Mission Ridge. The proposed line would remain parallel to circuit 5L42 through this segment. With the exception of an isolated small earth slide which could be avoided, there are no significant technical features in this segment. Existing roads would provide much of the necessary construction access.

6.2.5 ANDERSON (G-H)

From the 1828 metre elevation summit of Mission Ridge, the route descends through the Seton Lake Indian Reserve parallel to existing circuit 5L42. The combination of the elevation, location, and exposure of Mission Ridge presents a situation where high winds, and heavy ice and snow accumulation can occur. The design of 5L42 in this area was significantly increased recognizing this potential. This resulted in the use of a large single conductor with very heavy towers (See Photo 15). The design of the new proposed line would also have to be increased. This may not be to the same degree that 5L42 was. The operating experience of 5L42 would be used to determine the loading parameters of the new line. Further investigation into this would be necessary.

South of Whitecap Creek, the proposed line would leave 5L42 and cross circuits 3L2 and 2L2 to get to the right-of-way presently occupied by circuit 2L1. Further investigation is required to

Photo 24 Looking south at the Birken/Gates Lake Valley. Note proposed route.

Photo 25 The Birkenhead River valley near the Lokla Indian Reserve, looking north.

establish the optimum location of these cross-overs. In this segment, it is proposed to utilize the 2L1 right-of-way for the new 500 kV line. Construction access for much of circuit 2L1 was provided by the BC Railway. It is anticipated that for the construction of the new 500 kV line, new roads would likely be constructed to some of the tower sites. There are some areas of steep sidehill that would warrant careful tower placement and construction, but the majority of this segment does not present any serious technical difficulties.

At D'Arcy, through the Anderson Lake Indian Reserve, it is proposed to leave the 2L1 right-of-way and locate the new line higher on the hillside adjacent to existing line 3L2. Although the sidehill is somewhat steeper, this variation poses no technical concern (See Photo 6).

6.2.6 GATES LAKE (H-J)

This segment follows the main D'Arcy to Pemberton valley. It contains Highway 99, the BC Railway, and 4 existing transmission lines (circuits 5L42, 3L2, 2L2, and 2L1). Much of this segment is in a congested narrow steep-sided valley with some avalanche hazard (See Photo 24). As much of the 2L1 right-of-way is located on the valley floor adjacent to rural settlement, and its alignment contains numerous costly angles, there exists an opportunity to reduce construction costs and arguably improve the land use by locating the new line up on a series of benches above the valley floor. Further investigation to determine the precise location would be necessary. Cross-overs of the existing lines, construction on steep rock and talus slopes, and the security risk of slides and avalanches as well as the hazards of potential river erosion, are some of the technical factors to be considered in this segment (See Photos 8 and 25). The Lokla Indian Reserve is situated on the valley bottom beside Highway 99 approximately 3 km north of Node J. Avoiding this reserve could be a critical factor in assessing routing alternatives within this segment.

Creekside Capacitor Station is also in this segment. Should this route be selected, the station would be enlarged to accommodate capacitors for the new line. Consideration would have to be given to the approach of this site. This expansion would take place on property owned by BC Hydro (See Photo 13).

6.2.7 DUFFEY LAKE (F-J)

This route segment starts at the south side of the Bridge River, near its confluence with the Fraser River. The route then follows the Fraser River south to Lillooet, then traverses the hillside above Lillooet, crosses the Seton River, then turns up and follows Cayoosh Creek (See Photo 10). The line would follow Cayoosh Creek to Duffey Lake and through to the Lillooet River valley. Locating a 500 kV transmission line through this corridor would be difficult and costly. The north end of Cayoosh Creek is an extremely steep rocky canyon. Construction would be very difficult and the line would require a large number of heavy angles. Construction access would be demanding and much helicopter work would be anticipated. In the vicinity of Duffey Lake, numerous avalanches would pose a threat to the security of the line (See Photo 38). Where the line enters the Lillooet River valley, just north of Lillooet Lake, the route intersects the 3L2 right-of-way and parallels it back through the Mount Currie Indian Reserve to Node J north of Pemberton.

Photo 26 South end of Birkenhead Lake.

6.2.8 PEMBERTON (J-K)

This relatively short segment crosses the Lillooet River valley at Pemberton. The first 5 km utilizes the 2L1 right-of-way. Across the valley floor, 2L1 is located closer to the village of Pemberton. To avoid the development of the Village of Pemberton, the route parallels existing circuit 5L42 somewhat further away from town (See Photo 44). Further investigation would be necessary to establish the preferred side of 5L42. Cross-overs of existing lines could be required. The line continues to follow the 5L42 alignment through Nairn Falls Park. No technical difficulties are anticipated with this segment.

6.2.9 BIRKENHEAD (H-I)

This segment starts at Node H at D'Arcy, then goes up the Blackwater Creek to Birkenhead Lake Provincial Park, follows the south-east shore of Birkenhead Lake to Node I on the southern park boundary (See Photo 26). Some road development would be necessary for construction. Some snow slides or avalanches could be anticipated due to the heavy snowfall and steep sideslopes.

6.2.10 OWL (I-K)

From Node I on the southern end of Birkenhead Lake, this segment climbs to the 1500 m elevation of the alpine areas of Fowl and Owl creeks before descending to and crossing the Lillooet River valley just north-west of Pemberton. There would be high ice and wind loadings along this route due to the high elevation and exposure. Snow slide and avalanche hazards exist. The area is presently inaccessible by road. Extensive use would have to made of helicopters for all construction activities. The route then crosses the Lillooet River valley west of Pemberton towards Pemberton Meadows. It then traverses a bench above town across Pemberton Creek before descending and crossing Highway 99 immediately west of Nairn Falls Provincial Park. The steep descent into the Lillooet River valley would also require careful attention in regard to tower location and construction methods to avoid erosion problems.

6.2.11 GREEN RIVER (K-L)

This very short segment follows the eastern side of the Green River near Tisdall. Although the valley contains 3 existing lines, including 2L1, it proposed in this area to abandon the 2L1 right-of-way in favour of a new alignment on the east side of the valley. The proximity of 2L1 relative to Highway 99 and the approach to Pemberton from the south was the key factor in this decision. Some new road access would have to be developed, but no technical problems are anticipated in this route segment.

6.2.12 SOO RIVER (L-M)

From Node L in the Tisdall area of the Green River, this segment crosses the main valley, including all three existing transmission lines, Highway 99, and the BC Railway. It then follows the Soo River to Node M. Recent logging in the Soo has resulted in new access roads being

Photo 27 Green Lake at Whistler. Note location of existing lines as well as proposed line.

Photo 28 Avalanche paths of Rainbow Pass.

constructed on both sides of the valley. Further investigation is necessary to determine the most desirable side of the valley for the line location, for both environmental and engineering parameters (See Photo 30).

6.2.13 RYAN RIVER (I-M)

From Node I at the southern end of Birkenhead Lake, this segment ascends Tenas Creek to the alpine areas of Ogre Lake before descending into and crossing the Lillooet River valley. After crossing the valley, the route follows Ryan Creek, ascending to the 1600 metre elevation before crossing into the Rutherford Creek valley. The route then again ascends to the 1600 metre elevation to cross into the Soo valley to Node M. This would be an extremely difficult and expensive route for a 500 kV transmission line. The security of the line would also be questionable, due to avalanches and the severe exposure to high ice and wind conductor loadings in the high alpine passes (See Photos 9 and 11). Construction would be difficult as a result of the limited existing access and the obstacles associated with creating new roads.

6.2.14 RAINBOW PASS (M-N1-N)

This segment runs from the Soo River through to the Callaghan valley via the pass to the west of Rainbow Mountain. The line would reach an elevation of 1400 m and line location would have to consider snow movement and avalanching in the pass. (See Photos 14 and 28) High wind and ice conductor loadings would also be necessary for a short section. Some extra measures for avalanche protection would have to be considered. With the exception of the immediate pass area, there is existing road access along the route. The narrow pass and the potential for rock and snow slide activity would preclude being able to locate any more than two transmission lines in this segment. Establishing two lines would be possible, but the location of the first line would have to take into consideration the location of the second. This would result in the security of both lines being somewhat compromised (See Photo 35).

6.2.15 WHISTLER (L-N)

From Node L near Tisdall, this route segment follows the main valley south to the vicinity of Brandywine Falls Provincial Park. Presently there are three existing transmission lines (5L42, 2L2, and 2L1), Highway 99, and the BC Railway located in this corridor. Throughout this segment, a mixture of right-of-way alternatives are available for the proposed line. Some use of the 2L1 right-of-way, new right-of-way adjacent to 5L42, and a new separate right-of-way are options that could be utilized in this section. Access throughout the segment is good from either the existing transmission facilities, logging, or other development in the valley. No areas of extreme climatic exposure or avalanche activity are present. BC Hydro has experienced tower failures resulting from erosion on both the Green River and Rutherford Creek in the past (See Photos 39 and 40). The proposed line would not be located in these hazardous areas. A short section of the line may cross rock debris from the Green River slide.

Along the east side of Green Lake, three existing lines are located. 2L1 and 2L2 are located low, close to the shoreline. 5L42 is higher up the hillside. The proposal in this segment is to locate the new line up adjacent to 5L42. The removal of 2L1 would eliminate one of the more visible lines along the lakeshore (See Photo 27).

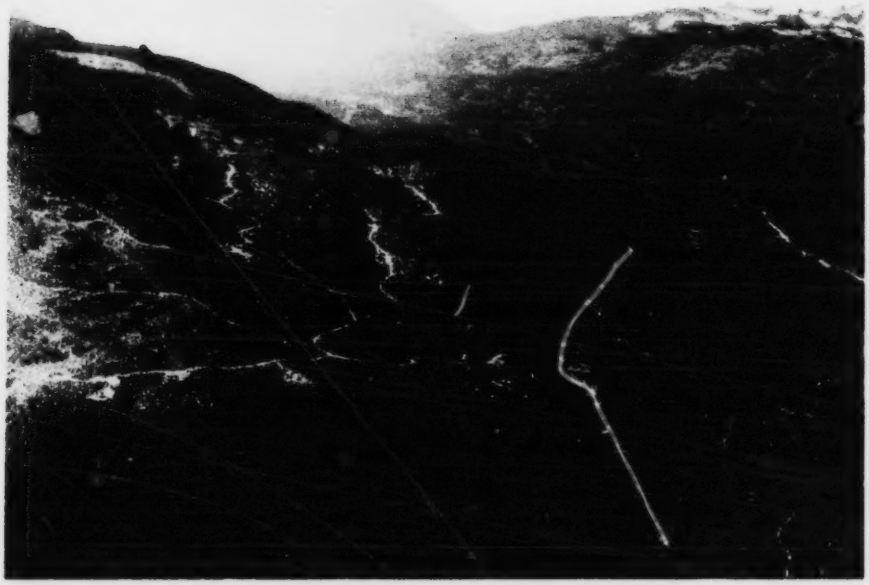

Photo 29 Logged area on east side of valley south of Whistler. Note 5L42 alignment and proposed routing of new line.

Photo 30 Looking west up the Soo River valley.

From the south end of Green Lake through to Alta Lake, along the River of Golden Dreams, the proposed line would replace 2L1 between 2L2 and 5L42.

Along the west side of Alta Lake, 2L1 was relocated to the higher bench. Its original right-of-way was used for 5L42 in 1969. (See photo 5) The new line would follow the existing 2L1 alignment for approximately 2 km before diverging behind a small hill. This 2L1 right-of-way would have to be widened to accommodate the new 500 kV line (See photo 49). From the south end of Whistler, 2L1 is presently located in close proximity to Highway 99. (See photo 4) Constructing the proposed line on the east side of the valley parallel to 5L42 would be both environmentally and technically desirable. At Node Y, the route leaves the 5L42 alignment to take a more direct route over a logged ridge. This route has the advantage of being shorter, less visible, and has access available from the logging activity in the area (See Photo 29).

The line would then descend and cross Daisy Lake again parallel to 5L42. The crossing of Daisy Lake would require special attention to establish the optimum tower locations.

6.2.16 CHEAKAMUS RIVER (N-P-Q-R)

From the north end of Daisy Lake, this route segment uses the 2L1 right-of-way through to the north end of the Cheakamus Canyon near the Pinecrest and Black Tusk subdivisions. At the Cheakamus Canyon, the line would leave the existing right-of-way and stay high on the west side of the valley. This would avoid a number of costly angle towers necessary to stay on the 2L1 alignment and keep the line out of the scenic canyon area in close proximity to Highway 99. South of the canyon area, just north of Culliton Creek, the route rejoins the 2L1 right-of-way through to Cheekye Substation (See Photo 12). This has potential conflicts from the additional clearing necessary for the new line with the many residents along the existing right-of-way, and the North Vancouver Outdoor School. This route also traverses the Cheakamus Indian Reserve. Three further sub-options within this segment have been investigated. They are as follows:

a) **Cheakamus South.** From Node R the route crosses the Cheakamus River and rises to the east side of the valley to Node S. The route continues on this high bench between the highway and the Cheakamus River until Node Z. Here the route intersects and follows the existing 500 kV lines that loop in and out of Cheekye Substation.

b) **Cheakamus West.** From Node P continue on the west side of the valley and do not cross until Node R. Continuing to Cheekye Sub via either R and T, or S, Z, and T. This would be somewhat more difficult to construct due to the steep rocky sidehill and limited ground access. This alignment could intrude on the viewscape of the Tantalus Range from Highway 99.

c) **Cheakamus East.** From Node Q the line crosses to the east side of the valley and stays high above the valley bottom via S, Z, and T. This section would also be somewhat more difficult to construct due to the steep rocky topography and limited ground access. It would also be more visible from Highway 99.

Photo 31 Anderson Lake viewed north from D'Arcy. Note long span across lake in Segment H1-H2.

Photo 32 Looking north-west up the Bridge River near the confluence of Antoine Creek. Note the Camelsfoot Bend.

6.3 ROUTE SEGMENTS (1990)

These are the route segments and route options that evolved from the Public Consultation Program, and from the need to identify route alternatives that by-passed Indian Reserves.

6.3.1 PAVILION EAST (W-W1-D-E)

Departing from the existing transmission right-of-way just before the north boundary of the Pavilion Indian Reserve, this route crosses the Pavilion Creek valley east of the native community of Pavilion (See Photo 45). It then traverses the bench south of the townsite before descending and crossing Highway 12, existing lines 2L90, 2L91, 5L41, and the BCR. The line would then cross some cultivated fields before spanning the Fraser River. More cultivated fields would be traversed before rejoining 5L42 on its ascent of the east face of the Camelsfoot Range.

Existing logging roads could provide some of the ground access. Additional roads would be required nonetheless. It is anticipated that the Pavilion Creek valley would be crossed in one span, thus avoiding locating a tower in the valley bottom beside the highway. The crossing of the existing lines near Node D however would be difficult, requiring tall towers on the potentially unstable slopes above the railway. Care would have to be taken in determining the location of the towers on either side of the Fraser River crossing. In this area the banks of the river are characterised by steep, very erodible slopes.

6.3.2 PAVILION SOUTH (C-D)

This option would utilize the existing unoccupied right-of-way on the east side of 5L41 through the Pavilion Indian Reserve. Once beyond of the south boundary of the reserve, the line would join segment DE and cross the Fraser River. The highway and railway crossing plus the crossing of 5L41 at Node D are the only technical considerations of this segment.

6.3.3 FRASER SOUTH (W1-F1)

From the south side of Pavilion Creek (Node W1) this segment proceeds south-west across the bench above the highway and existing transmission lines. It then descends, crossing these existing lines and then the Fraser River. On the west side of the Fraser River the line climbs the slopes of the Camelsfoot Range and rejoins 5L42. There is presently very little developed road access along this segment. Care would have to be taken in selecting tower sites on either side of the Fraser to ensure stable sites. The addition of a new separate river crossing could impose a hazard to aviation.

6.3.4 BRIDGE RIVER (F1-X-V-G)

From the north face of the Camelsfoot Range, this route segment leaves the existing 5L42 right-of-way and ascends into the upper region of Lee Creek. It then crosses over the Camelsfoot and decends into and crosses Applespring Creek. From Applespring Creek, the route follows the

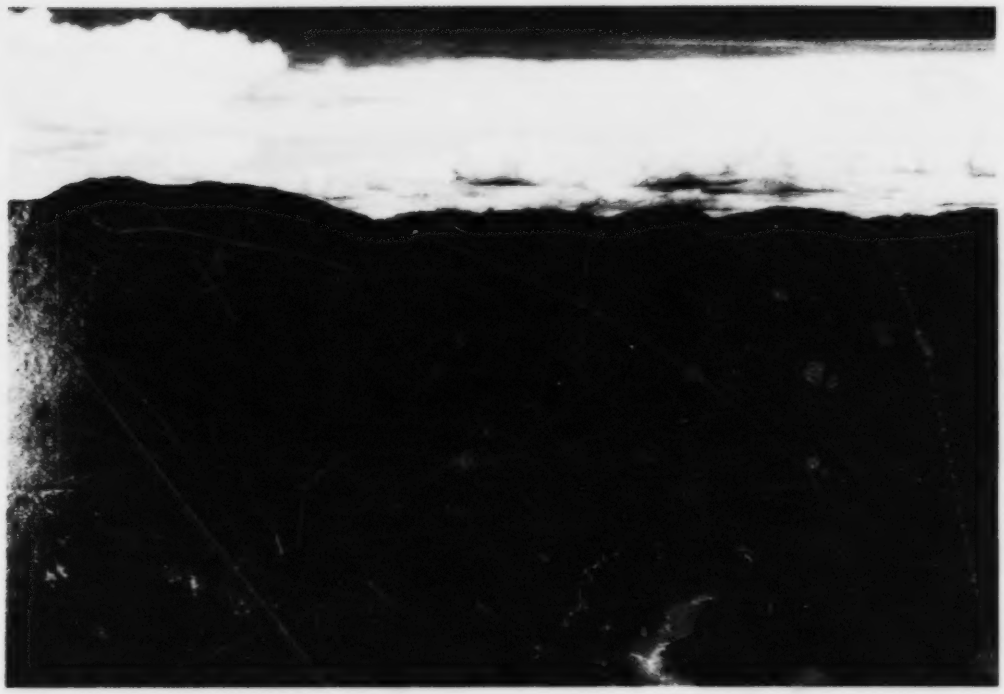

Photo 33 Existing 5L42 looking north from the confluence of the Bridge and Fraser Rivers.

Photo 34 Looking north toward the industrial park of the Function Junction area of Whistler.

north side of the Bridge River valley to Antoine Creek. After crossing Antoine Creek, the line would cross the Bridge River and follow segments XVG south to Mission Ridge (See Photo 32). Access could be extended into the upper section of Lee Creek from existing logging roads in the area. The west side of the Camelsfoot and into Applespring does not presently have any road development and the steep ridges of the area would make road construction difficult. On the north side of the Bridge River where the line would be located on the slopes above the highway, care would have to be taken in road construction to ensure that the stability of the slopes is not jeopardized (See Photo 47).

With the exception of a few old small avalanche tracks near the summit of Lee Creek, there are no apparent hazards to the line despite the high elevation and steep slopes of the segment.

6.3.5 SETON (G1-G2)

In this route option the proposed line avoids crossing the Seton Indian Reserve, IR 5A. The line would diverge from the existing alignment of 5L42 above the reserve, south of Mission Ridge, and stay high above the north boundary of the reserve. It would then converge back to 5L42 at the crossing of Whitecap Creek, east of the reserve boundary. Road access could be extended from the existing roads to and along the existing 5L42. The only technical consideration in this alternative is the crossing of Whitecap Creek where a span over 1500 metres in length would be required. A span of this length would not present any insuperable technical problems (See Photo 46).

6.3.6 D'ARCY (H1-H2)

One alternative to avoid crossing the Anderson Lake Indian Reserve at D'Arcy is to follow segment H1-H2. This would require a long (2000 metre) span across Anderson Lake. This long span would require special towers. Once on the east side of the Lake, relatively few technical difficulties are encountered. Road access could be readily developed. The long crossing span would be a potential aviation hazard (See Photo 31).

6.3.7 FUNCTION JUNCTION (Y1-Y)

This option would utilize the 2L1 right-of-way on the west side of the valley behind the industrial development of Function Junction. Although this segment would be slightly longer than the 5L42 alignment, it offers an advantage in the approach to the cross-over of 5L42 at Node Y. Access would be good, and there are no technical difficulties other than the transmission line crossovers required (See Photo 34).

6.3.8 HIGH CHEAKAMUS (Y-Y2-Z)

From Function Junction south to Cheekye this route stays high on the east side of the valley. It is located high above Daisy Lake on a bench where there are areas of active logging. Construction could take advantage of the access provided by this logging. Clearing would also benefit from the logging. There are no hazards from snow slides or avalanches and despite being

Photo 35 The south side of Rainbow Pass and the Callaghan Lake area.

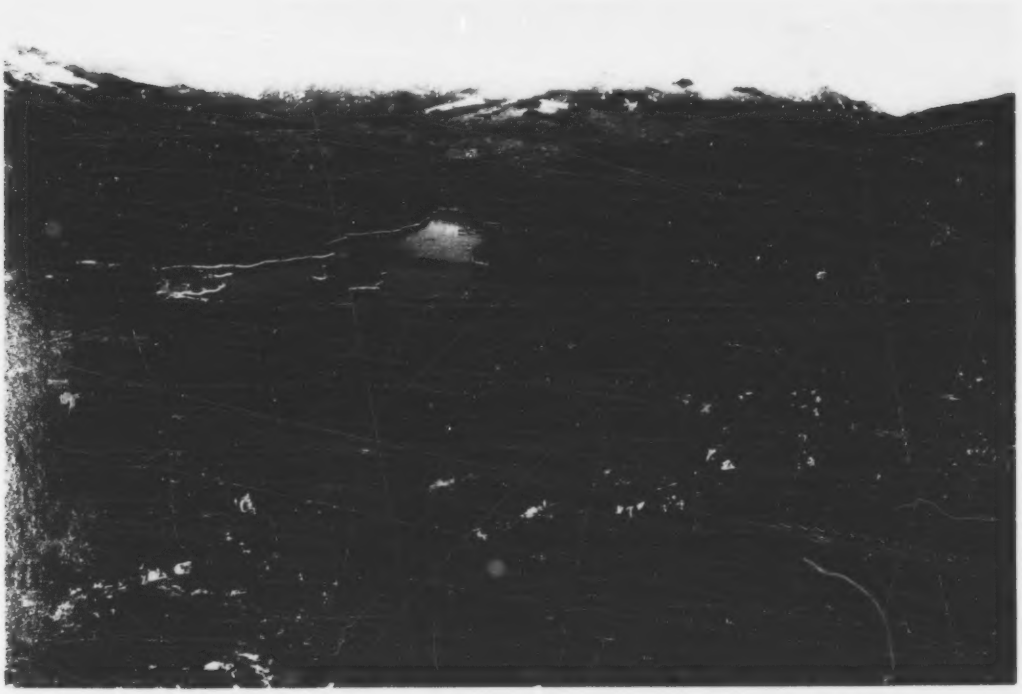

Photo 36 The south end of Daisy Lake. Not proposed routing high on east side of lake.

higher than the valley floor, the wind and ice loadings would be within acceptable limits of design. After crossing Rubble Creek, the line would stay above existing 5L42. The extent to which it is away from this existing line would require further investigation. The intent would be to establish an alignment which is screened from view to the greatest extent practicable (See Photo 36). The broken undulating topography, together with the intermittent vegetation cover, provides a good opportunity to locate the new line in a location that is not obvious from the valley floor and Highway 99. The terrain is predominately rock through this section. Some access does exist from old logging and the construction of 5L42. It is anticipated that the rock slopes would however, require some helicopter construction. The slopes are considered stable with little potential for hazards to the line (See Photo 48).

6.3.9 CHEAKNORTH (Y-Y2)

This is a short segment that connects the route on the valley floor at Whistler, to the High Cheakamus. It essentially is a slow climb through a logged area to the bench above Daisy Lake. This logging would provide ready road access and reduce the amount of clearing necessary. There are no apparent hazards in this segment.

6.3.10 CALLAGHAN (N1-Y2)

This segment connects the Rainbow Pass and the High Cheakamus alternatives. It traverses the south face of Mount Sproat, and crosses the Cheakamus valley just north of McGuire. Existing lines 2L2 and 5L42 as well as Highway 99 would have to be crossed in this segment. Access could be provided by existing roads in the area and no potential hazards are apparent.

Photo 37 An avalanche damaged tower.

Photo 38 Avalanches along Duffey Lake route

7.0 TECHNICAL EVALUATION

Table 7-1 shows the factors that reflect the degree of technical difficulty associated with the construction of a 500 kV transmission line. Each of the four evaluation factors has been given five ratings ranging from Low to Extreme.

A description of the four Technical Evaluation factors in Table 7-1 is as follows:

a) **Design:** There are three independent considerations affecting the design of a transmission line. Each segment was rated according to the consideration warranting the most severe rating. These considerations are:

   i) Topography. The more severe the sideslope, the more difficult and expensive the line is to construct. Taller structures are necessary or tower spacing is reduced and as a result more towers are required. Longer leg extensions on the towers are necessary and tower sites need more preparation, such as benching.

   ii) Conductor Loading. The more severe the anticipated conductor ice and wind loadings are, the stronger and heavier the towers have to be.

   iii) Percentage of Deflections. Deflections (or angles in the line) require heavier towers. Consequently, the greater the percentage of large deflection angles, the more expensive the line becomes.

b) **Access:** The ratings for access reflect the availability of roads for the construction and maintenance of the transmission line. An area where good access already exists from linear developments such as other transmission lines, pipelines, or highways will warrant a low rating. The rating will increase as the availability of existing roads decreases and as new access becomes increasingly difficult to construct. Areas that are considered to be inaccessible to ground vehicles and require helicopter access are given the most severe ratings.

c) **Clearing:** The ratings for the clearing increase as the difficulty and cost of clearing the right-of-way increases. Areas that cannot be cleared by machinery due to their sensitivity to erosion, steep side slopes, wetness, final appearance, environmental, or other considerations and which therefore must be cleared by hand held equipment, are given high ratings.

d) **Specialized Construction:** This includes items such as spans exceeding 1000 metres in length, tower legs designed to withstand snow movement, avalanche protection, erosion protection, pile foundations, special towers such as extra strong or extra tall towers, or anything else that would warrant specialized construction techniques.

After a comprehensive study of all of the route segments a comparative rating for each of the four factors with reference to Table 7-1 was assigned to each of the 51 segments. The ratings assigned to each of the 51 route segments of this project are summarized in Table 7-2. Although it is not possible to arithmetically combine these ratings for the segments, these factors that make up these ratings contribute to the derivation of segment costs.

	RATINGS				
	LOW	MODERATE	MEDIUM	HIGH	EXTREME
DESIGN • Topography • Conductor Loading • Line Deflections	• No Sidehill • Light Loading • Low % of Deflections	• rolling, some sidehill • Normal Loading • moderate % of Deflections	• Below 20° sidehill • Higher than normal loading • Medium % of Deflections	• Over 20° sidehill • High Loading • High % of Deflections	• Over 30° sidehill • Extreme Loading • Individual Site Selection
ACCESS	Good access from existing roads from other linear developments.	Roads to line at frequent points; not far from existing roads; new road construction easy.	Some roads; new road construction possible; helicopter access is minimal	No existing access roads; new road construction would be difficult. Some helicopter access.	Road construction not practicable; helicopter access only.
CLEARING	Little clearing required; range land with scattered individual trees.	Easy machine clearing; minimal hand clearing required.	Machine clearing, some hand clearing required.	Mostly hand clearing, with some machine.	Total hand clearing
SPECIALIZED CONSTRUCTION	None	Minimal	Some	High	Very High

Table 7-1 Technical Factors

	SEGMENT NAME	NODE POINTS	TECHNICAL EVALUATION COMPONENTS			
			DESIGN	ACCESS	CLEARING	SPECIALIZED CONSTRUCTION
1	KELLY LAKE	A-B	MEDIUM	LOW	MEDIUM	LOW
2	DIAMOND	B-W	LOW	LOW	LOW	LOW
3	PAVILION	W-C	MODERATE	LOW	LOW	LOW
4	FRASER NORTH	C-E	MEDIUM	MODERATE	LOW	MEDIUM
5	CAMEL NORTH	E-F1	MEDIUM	MODERATE	MODERATE	LOW
6	CAMEL SOUTH	F1-F	MEDIUM	MEDIUM	MODERATE	HIGH
7	MARBLE NORTH	W-W1	MEDIUM	MEDIUM	MEDIUM	LOW
8	MARBLE SOUTH	W1-D	MODERATE	MEDIUM	MODERATE	LOW
9	FRASER MID	D-E	MODERATE	MODERATE	LOW	MEDIUM
10	PAVILION SOUTH	C-D	MODERATE	LOW	LOW	LOW
11	FRASER SOUTH	W1-F1	MEDIUM	MODERATE	MODERATE	MEDIUM
12	CAVANAGH	B-U	HIGH	HIGH	HIGH	HIGH
13	ANTOINE	U-X	HIGH	HIGH	MEDIUM	MEDIUM
14	BIG BEND	X-V	MEDIUM	MODERATE	MEDIUM	LOW
15	ORE CREEK	U-V	MEDIUM	MEDIUM	MEDIUM	LOW
16	BRIDGE	F1-X	HIGH	HIGH	MEDIUM	MODERATE
17	NORTH RIDGE	V-G	MEDIUM	MEDIUM	MEDIUM	LOW
18	MISSION	F-G	MEDIUM	MODERATE	MEDIUM	LOW
19	RIDGE	G-G1	EXTREME	MODERATE	HIGH	HIGH
20	SETON	G1-G2	MEDIUM	MEDIUM	MEDIUM	MODERATE
21	SETON RESERVE	G1-G2	MEDIUM	MODERATE	MODERATE	MODERATE
22	ANDERSON	G2-H1	MODERATE	MEDIUM	MODERATE	LOW
23	D'ARCY	H1-H	MODERATE	MEDIUM	MODERATE	LOW
24	D'ARCY SOUTH	H-H2	MODERATE	MEDIUM	MODERATE	LOW
25	D'ARCY EAST	H1-H2	EXTREME	MEDIUM	MEDIUM	EXTREME
26	GATES	H2-J	MEDIUM	MEDIUM	MEDIUM	LOW
27	DUFFEY	F-J	HIGH	HIGH	HIGH	HIGH
28	PEMBERTON	J-K	LOW	LOW	LOW	MODERATE
29	BIRKENHEAD	H-I	MEDIUM	MEDIUM	MEDIUM	LOW
30	OWL	I-K	EXTREME	HIGH	HIGH	HIGH
31	GREEN RIVER	K-L	LOW	MEDIUM	MODERATE	LOW
32	SOO RIVER	L-M	MEDIUM	MODERATE	MEDIUM	MODERATE
33	RYAN	I-M	EXTREME	HIGH	HIGH	HIGH
34	RAINBOW PASS	M-N1	HIGH	HIGH	HIGH	HIGH
35	WHISTLER	L-Y1	LOW	MODERATE	MODERATE	LOW
36	FUNCTION 5L42	Y1-Y	LOW	LOW	LOW	MODERATE
37	FUNCTION WEST	Y1-Y	MODERATE	LOW	MODERATE	LOW
38	DAISY	Y-N	MODERATE	MODERATE	MEDIUM	LOW
39	HIGH CHEAKAMUS	Y2-Z	MEDIUM	MEDIUM	MEDIUM	MEDIUM
40	CANYON	N-P	MEDIUM	MODERATE	MODERATE	MODERATE
41	CANYON CROSS	P-Q	MEDIUM	HIGH	HIGH	LOW
42	CHEAKAMUS EAST	Q-S	HIGH	HIGH	HIGH	MODERATE
43	UPPER CHEAKAMUS	Q-R	LOW	LOW	LOW	MODERATE
44	NORTH LOOP	S-Z	MEDIUM	MEDIUM	MEDIUM	MODERATE
45	CHEAKAMUS WEST	P-R	HIGH	HIGH	HIGH	MODERATE
46	LOWER CHEAKAMUS	R-T	MEDIUM	LOW	LOW	LOW
47	WOUNTIE	R-S	HIGH	HIGH	HIGH	MODERATE
48	LOOP	Z-T	LOW	LOW	LOW	LOW
49	BRANDYWINE	N1-N	MODERATE	MEDIUM	MEDIUM	LOW
50	CALLAGHAN	N1-Y2	MODERATE	MODERATE	MEDIUM	LOW
51	CHEAKNORTH	Y-Y2	MODERATE	MEDIUM	MEDIUM	LOW

Table 7-2 Technical Evaluation

Photo 39 Existing lines near Tisdall Capacitor station at the confluence of Rutherford Creek and the Green River.

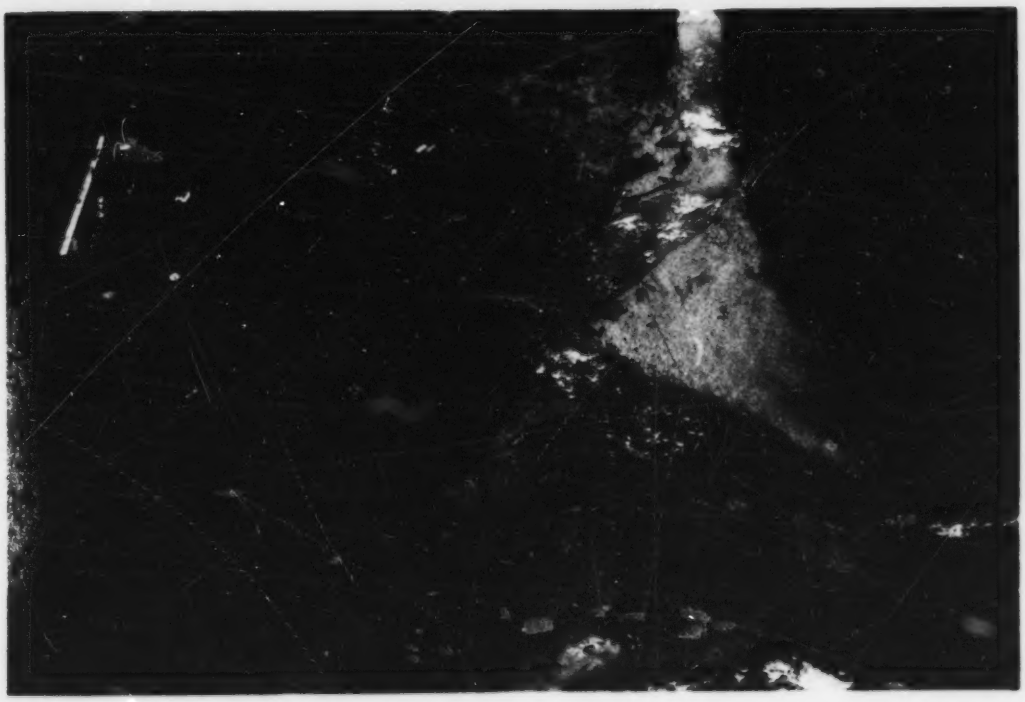

Photo 40 Same location as Photo 38 after flooding. Note erosion of river bank where tower was destroyed.

8.0 SECURITY EVALUATION

A major consideration in the evaluation of transmission line routes and route segments is the aspect of line security. System integrity and operating cost are dependent on the reliability of BC Hydro's transmission lines. The safety of workers called upon to repair lines in the event of line failures is also a consideration. BC's rugged coastal mountains pose a wide variety of hazards that threaten transmission line security. These hazards have been compiled into four broad categories and have been given a rating ranging from Nil to Extreme. Table 8-1 shows these security hazards and descriptions of the ratings. The following is a description of the four categories of hazards.

a) **Avalanche or snow slide:** Snow and ice avalanches can be a severe hazard to transmission facilities because of their high velocities, high impact pressures, associated air blasts, and debris carrying characteristics. Areas prone to avalanching generally have high local relief and abundant snowfall (See Photo 37).

b) **Slope Failure:** There are numerous types of slope failures which can cause damage to a transmission line. These can include large scale rock slides, mud slides, and debris flows. Areas with high local relief and abundant precipitation are susceptible to slope failures (See Photo 41).

c) **River Erosion:** Flooding and river erosion have a high potential to cause failure of a transmission line. Flood waters can undermine tower footings or cause damage with floating logs and debris. River banks can erode great distances in a single flood and small creeks can become raging torrents in a few hours during heavy rainfall and during snowmelt (See Photos 39 and 40).

d) **Extreme Wind or Ice Accumulation:** Ice accumulation and wind loading can cause collapse of towers and breakage of conductors or hardware. Ice accumulation on insulators can cause electrical faults resulting in the disruption of service. Large amounts of ice can form when fog or clouds pass slowly by structures and conductors at freezing temperatures or when moisture is deposited by freezing rain in conjunction with high wind velocities and freezing temperatures. Strong winds can cause damage by imposing high loads on structures and conductors either by direct force or by setting the conductor in motion causing circuit interruptions due to contact between conductors. Severe ice and wind loadings can occur simultaneously and their combined effect can be devastating to transmission structures (See Photo 43).

The assessment of the transmission line route segments was made with regard to these hazards. This security evaluation cannot be arithmetically or quantitatively tabulated and compared in the same manner that construction costs can. The assessment of the security of transmission line routes or route segments, was based on engineering judgement and experience with line construction and maintenance. Table 8-2 summarizes all 51 route segments and the degree to which they are judged to be exposed to each of the hazards described above.

Recognition of these potential hazards is the first step in maximizing transmission line reliability. To some degree these hazards can be dealt with by various protection measures. For example, where routing requirements necessitate the placement of towers on steep slopes in an area of high snow accumulation, self-supporting towers with legs designed for the increased pressure of snow creep would be used. Where conditions are such that snow slides are anticipated, protective berms or deflectors would be installed. Similarly in areas of potential creek or river erosion, rock berms installed at the tower base would provide some protection in the event of high water flow or washout (See Photo 42). In high exposed regions, heavier than normal wind and ice accumulation can be expected. Here, heavier design loads on the tower and conductor are used.

These preventative measures are all expensive and can provide only a partial improvement in line security. They do not guarantee the safety of the line. Avoidance of the hazardous areas is the surest way to prevent catastrophic failures.

	RATINGS				
	NIL	LOW	MEDIUM	HIGH	EXTREME
AVALANCHE or SNOW SLIDE	No occurrence, present or anticipated.	No existing paths. Some potential for isolated snow slides after R/W clearing.	Some small confined avalanche paths that can be spanned or avoided; some tower protection.	Numerous avalanche paths; avoidance and/or tower protection is difficult.	Numerous, unconfined paths; avoidance and/or tower protection impossible
SLOPE FAILURE	No occurrence, present or anticipated.	Minimal potential for failures due to low relief.	Some potential for failure due to relief and/or geology of area. Careful tower site selection necessary.	Some existing slides in area, probability of future slides, even with careful tower site selection.	Existing slides, steep terrain; high probability of future slides, No opportunity of avoidance.
RIVER EROSION	No occurrence, present or anticipated.	Low relief; some well confined streams; little potential for erosion or washout.	Some potential due to proximity to either flood plain or water course. Minimal tower protection.	High potential, line close to flood plain or water course in steep mountainous area with heavy rainfall anticipated. Some tower protection.	Line located on floodplain in mountainous area prone to heavy rains. Extensive protection required.
ICE AND WIND LOADING	Light normal loadings	Normal loadings	Higher than normal loadings	High loadings; heavy structures required.	Very high loadings; special conductor and structures required.

Table 8-1 Security Hazard Factors

	SEGMENT NAME	NODE POINTS	HAZARD EVALUATION COMPONENTS			
			AVALANCHE	SLOPE FAILURE	RIVER EROSION	ICE LOADING
1	KELLY LAKE	A-B	NIL	LOW	NIL	LOW
2	DIAMOND	B-W	NIL	NIL	NIL	LOW
3	PAVILION	W-C	NIL	LOW	NIL	LOW
4	FRASER NORTH	C-E	NIL	MEDIUM	NIL	LOW
5	CAMEL NORTH	E-F1	NIL	MEDIUM	NIL	LOW
6	CAMEL SOUTH	F1-F	NIL	MEDIUM	LOW	LOW
7	MARBLE NORTH	W-W1	NIL	HIGH	LOW	LOW
8	MARBLE SOUTH	W1-D	NIL	MEDIUM	NIL	LOW
9	FRASER MID	D-E	NIL	MEDIUM	NIL	LOW
10	PAVILION SOUTH	C-D	NIL	LOW	LOW	LOW
11	FRASER SOUTH	W1-F1	NIL	LOW	LOW	LOW
12	CAVANAGH	B-U	LOW	HIGH	MEDIUM	LOW
13	ANTOINE	U-X	LOW	MEDIUM	LOW	LOW
14	BIG BEND	X-V	NIL	LOW	LOW	LOW
15	ORE CREEK	U-V	LOW	MEDIUM	LOW	LOW
16	BRIDGE	F1-X	LOW	MEDIUM	LOW	LOW
17	NORTH RIDGE	V-G	LOW	LOW	LOW	MEDIUM
18	MISSION	F-G	LOW	MEDIUM	LOW	MEDIUM
19	RIDGE	G-G1	LOW	LOW	LOW	EXTREME
20	SETON	G1-G2	LOW	LOW	LOW	MEDIUM
21	SETON RESERVE	G1-G2	LOW	LOW	LOW	MEDIUM
22	ANDERSON	G2-H1	HIGH	MEDIUM	LOW	LOW
23	D'ARCY	H1-H	LOW	LOW	LOW	LOW
24	D'ARCY SOUTH	H-H2	LOW	LOW	LOW	LOW
25	D'ARCY EAST	H1-H2	MEDIUM	LOW	MEDIUM	LOW
26	GATES	H2-J	MEDIUM	MEDIUM	MEDIUM	LOW
27	DUFFEY	F-J	HIGH	MEDIUM	MEDIUM	MEDIUM
28	PEMBERTON	J-K	LOW	LOW	MEDIUM	MEDIUM
29	BIRKENHEAD	H-I	MEDIUM	MEDIUM	MEDIUM	LOW
30	OWL	I-K	HIGH	HIGH	MEDIUM	EXTREME
31	GREEN RIVER	K-L	LOW	LOW	LOW	MEDIUM
32	SOO RIVER	L-M	MEDIUM	MEDIUM	MEDIUM	LOW
33	RYAN	I-M	HIGH	HIGH	HIGH	EXTREME
34	RAINBOW PASS	M-N1	HIGH	HIGH	MEDIUM	HIGH
35	WHISTLER	L-Y1	LOW	LOW	LOW	LOW
36	FUNCTION 5L42	Y1-Y	NIL	NIL	LOW	LOW
37	FUNCTION WEST	Y1-Y	LOW	LOW	LOW	LOW
38	DAISY	Y-N	LOW	LOW	LOW	LOW
39	HIGH CHEAKAMUS	Y2-Z	LOW	LOW	LOW	MEDIUM
40	CANYON	N-P	LOW	LOW	LOW	LOW
41	CANYON CROSS	P-Q	NIL	NIL	LOW	LOW
42	CHEAKAMUS EAST	Q-S	MEDIUM	MEDIUM	LOW	LOW
43	UPPER CHEAKAMUS	Q-R	NIL	NIL	MEDIUM	LOW
44	NORTH LOOP	S-Z	NIL	NIL	LOW	LOW
45	CHEAKAMUS WEST	P-R	MEDIUM	MEDIUM	LOW	LOW
46	LOWER CHEAKAMUS	R-T	NIL	NIL	MEDIUM	LOW
47	WOUNTIE	R-S	LOW	NIL	MEDIUM	LOW
48	LOOP	Z-T	NIL	LOW	LOW	LOW
49	BRANDYWINE	N1-N	LOW	LOW	LOW	LOW
50	CALLAGHAN	N1-Y2	LOW	LOW	LOW	LOW
51	CHEAKNORTH	Y-Y2	LOW	LOW	LOW	LOW

Table 8-2 Security Hazard Evaluation Table

Photo 41 Debris slide that destroyed 500 kV towers.

9.0 TRANSMISSION LINE COST ANALYSIS

9.1 METHODOLOGY

To provide comparative cost estimates for all the transmission line route alternatives in the study, each of the segments that comprise viable routes was assessed on the basis of factors that influence the cost of transmission line construction. These factors include:

- segment length
- tower type required (guyed vs self-supporting)
- quantity of towers required (tangent vs heavy angle)
- topography
- access (existing, new, or helicopter)
- clearing (area and method)
- timber compensation
- right-of-way acquisition
- protection (slide or avalanche, river erosion, etc)
- environmental mitigation

The latest available costs for the various materials and transmission line components were compiled. Labour costs were estimated for the main construction activities. Factors were then derived that could be applied to these base construction costs to reflect existing and new access development, and the extent to which helicopter construction would be necessary. Similar factors were derived to reflect the degree of difficulty the terrain would impose on transmission line construction.

Engineering costs on a per kilometre basis were then estimated. Engineering field activities would also be a function of the access and terrain factors.

Property acquisition costs and timber compensation values were also estimated for the study area.

For each of the route segments, the anticipated quantity of the various tower types, the area of clearing (both hand and machine), and the volume of merchantable timber were estimated. The severity of the terrain together with the extent of access (existing and required, ground and helicopter), were evaluated and rated for each segment. Costs of the various transmission line construction components were then calculated and a total cost for the particular route segment was tallied. These route segment costs were then combined to produce the comparative costs estimates for all the viable transmission line routes.

These estimates include the direct costs, plus an allowance for inflation and for indirect costs (e.g. corporate overheads and interest during construction) determined for the purpose of this report as 50% of the direct costs. Not included are costs associated with transmission line losses, transmission line maintenance, and any necessary removal of existing circuit 2L1, or any necessary expansion of Kelly Lake Substation, Creekside Capacitor Station, and Cheekye Substation.

Also not included for this comparison are common costs which include those associated with:

- legal services
- public consultation
- EMF support services
- project management

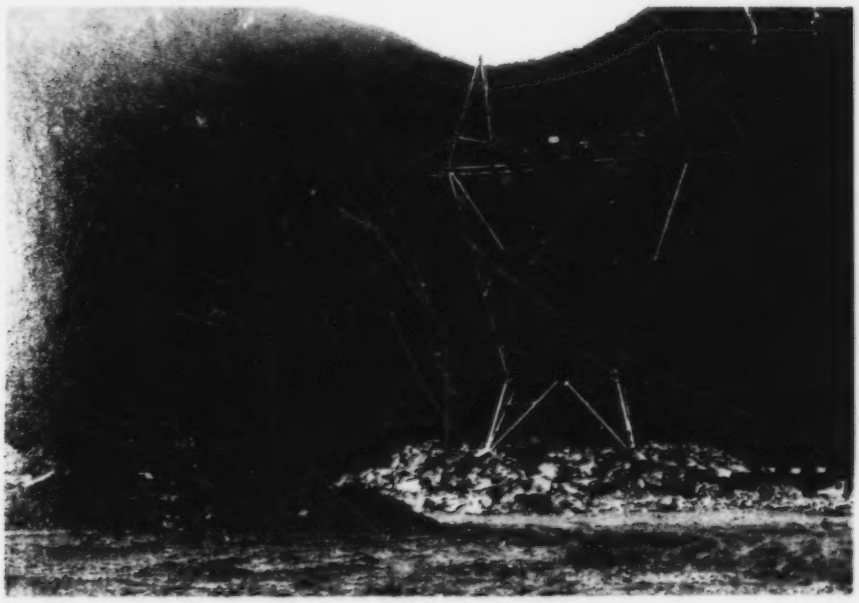

Photo 42 An example of rip-rap erosion protection on base of tower.

9.2 TRANSMISSION LINE COST COMPONENTS

The breakdown of costs will vary for every 500 kV transmission line route, or route segment. The factors given in Section 8.1 will influence the make-up of the transmission line costs. However in general, the estimated cost for the Kelly Lake - Cheekye project can be expected to be distributed approximately as shown in Figure 9-1.

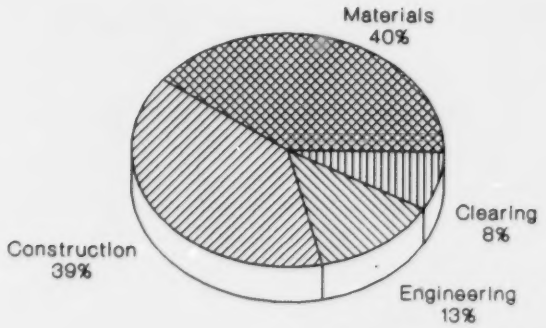

Figure 9-1 Distribution of Transmission Line Cost Components

The subsequent breakdown of the materials, construction, and engineering components of these costs are illustrated in the following three charts.

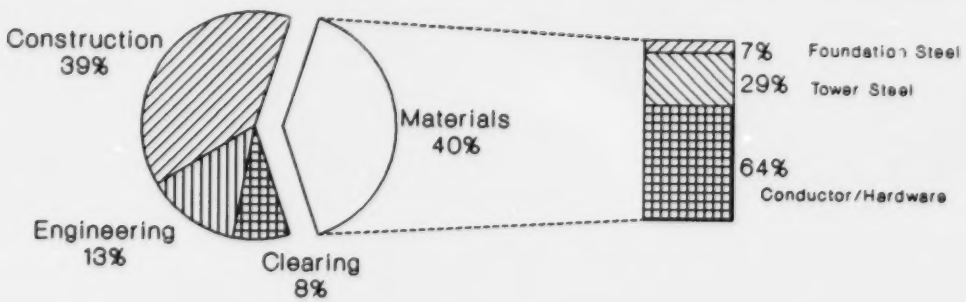

Figure 9-2 Material Cost Breakdown

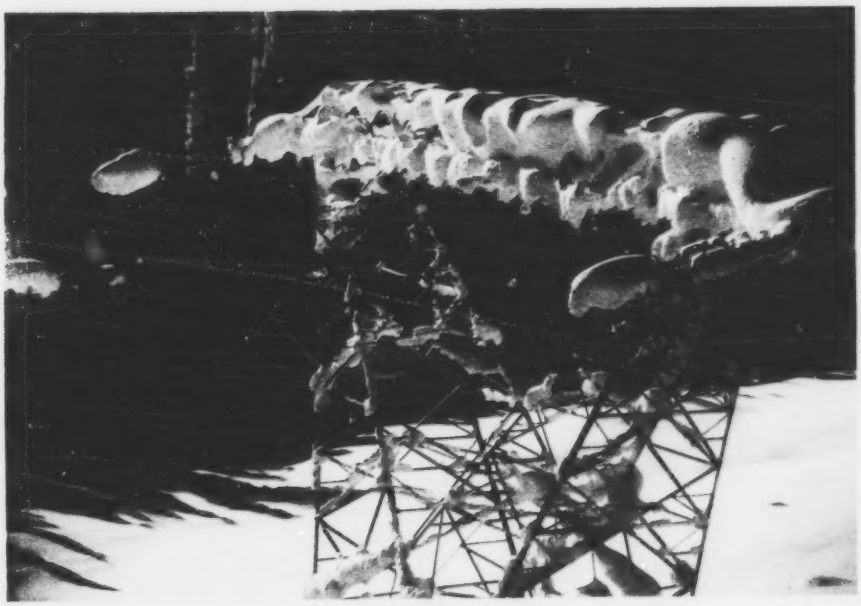

Photo 43 Ice and snow build up on tower.

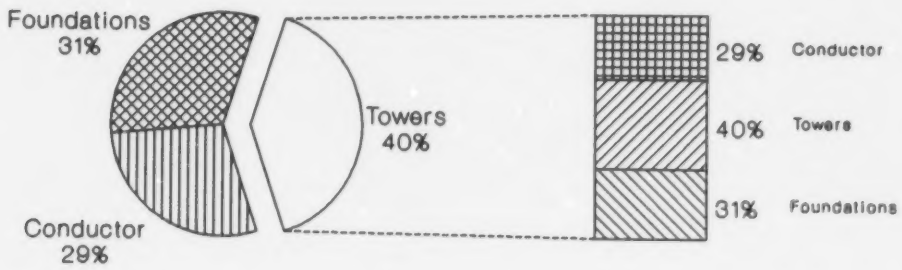

Figure 9-3 Construction Cost Breakdown

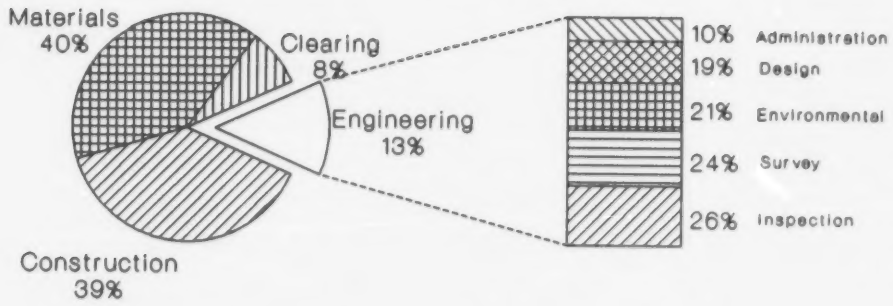

Figure 9-4 Engineering Cost Breakdown

9.3 SEGMENT COSTS

The route network outlined and described in Section 6 consists of 51 segments. The costs for these segments have been estimated in the manner detailed in Section 9.1. Table 9-1 summarizes these segments, their length, and their cost.

	SEGMENT NAME	NODES POINTS	LENGTH km	ESTIMATED COST ($000)
1	KELLY LAKE	A-B	6.0	3,912
2	DIAMOND	B-W	8.5	4,104
3	PAVILION	W-C	4.5	2,873
4	FRASER NORTH	C-E	6.5	3,876
5	CAMEL NORTH	E-F1	2.5	1,454
6	CAMEL SOUTH	F1-F	7.3	6,333
7	MARBLE NORTH	W-W1	5.0	3,823
8	MARBLE SOUTH	W1-D	2.3	1,572
9	FRASER MID	D-E	4.5	3,280
10	PAVILION SOUTH	C-D	1.3	992
11	FRASER SOUTH	W1-F1	8.5	6,831
12	CAVANAGH	B-U	12.0	12,010
13	ANTOINE	U-X	22.0	21,733
14	BIG BEND	X-V	3.3	2,589
15	ORE CREEK	U-V	38.0	28,071
16	BRIDGE	F1-X	19.0	21,849
17	NORTH RIDGE	V-G	7.0	5,922
18	MISSION	F-G	15.0	12,407
19	RIDGE	G-G1	9.5	11,157
20	SETON	G1-G2	5.5	5,081
21	SETON RESERVE	G1-G2	5.0	3,588
22	ANDERSON	G2-H1	17.0	11,200
23	D'ARCY	H1-H	8.0	4,856
24	D'ARCY SOUTH	H-H2	4.0	2,583
25	D'ARCY EAST	H1-H2	13.5	13,121
26	GATES	H2-J	23.5	19,761
27	DUFFEY	F-J	89.0	90,244
28	PEMBERTON	J-K	10.0	6,287
29	BIRKENHEAD	H-I	20.0	15,395
30	OWL	I-K	25.0	27,450
31	GREEN RIVER	K-L	2.0	1,551
32	SOO RIVER	L-M	18.0	16,685
33	RYAN	I-M	57.0	67,264
34	RAINBOW PASS	M-N1	14.0	14,795
35	WHISTLER	L-Y1	26.0	17,550
36	FUNCTION 5L42	Y1-Y	3.0	1,667
37	FUNCTION WEST	Y1-Y	3.3	1,974
38	DAISY	Y-N	8.0	6,404
39	HIGH CHEAKAMUS	Y2-Z	31.0	26,460
40	CANYON	N-P	12.8	10,850
41	CANYON CROSS	P-Q	2.1	2,308
42	CHEAKAMUS EAST	Q-S	10.0	10,148
43	UPPER CHEAKAMUS	Q-R	7.0	4,686
44	NORTH LOOP	S-Z	1.6	1,427
45	CHEAKAMUS WEST	P-R	10.0	10,463
46	LOWER CHEAKAMUS	R-T	4.6	3,328
47	WOUNTIE	R-S	2.7	2,538
48	LOOP	Z-T	1.8	1,144
49	BRANDYWINE	N1-N	9.0	6,667
50	CALLAGHAN	N1-Y2	6.7	4,963
51	CHEAKNORTH	Y-Y2	3.8	2,421

Table 9-1 Segment Lengths and Costs

9.4 ROUTE COSTS

The network of route segments investigated results in a great number of mathematically possible routes. To simplify the cost comparison of these routes, they have been broken down into what has been called main routes and sub-route options. The main routes are continuous routes from Kelly Lake through to Cheekye. The sub-route options are alternatives that could be used in conjunction with one or more of these main routes, replacing a portion thereof. Most of these sub-route options can be combined with more than one main route and more than one sub-route option could be used with each main route.

The total estimated cost of each of the five main routes and their lengths are given in Table 9-2.

The total estimated cost of each of the nine sub-route options and their lengths are given in Table 9-3. The length and cost values given in Table 9-3 are additional and represent the incremental increases over the values of the segments of the main routes replaced by the particular sub-route option.

9.5 2L1 REMOVAL COSTS

The costs involved in the dismantling and removal of the entire length of existing 230 kV transmission line circuit 2L1 are estimated to be approximately $11,000,000. This includes a salvage value of $800,000, primarily from the scrap value of the aluminum conductor. The cost of partial removal would be a function of the extent and location of the portion to be removed.

9.6 RETERMINATION OF 2L2 AT PEMBERTON AND RAINBOW SUBSTATIONS

Pemberton and Rainbow (Whistler) substations are presently connected to 230 kV transmission line 2L1. In the event of the removal of 2L1, these stations would have to be served exclusively by 230 kV transmission line 2L2. This would require the installation of short tap lines from 2L2. The cost of this work is estimated at $150,000. Associated station costs would be in the order of $1.8 million (including the appropriate indirect charges)

ROUTE	NODE POINTS	LENGTH km	ESTIMATED COST ($000)
5L42/2L1	A-B-W-C-E-F1-FG-G1-G2-H1-H-H2-J-K-L-Y1-Y-N-P-Q-R-T	192.8	142,735
Duffey Lake/2L1	A-B-W-C-E-F1-F-J-K-L-Y1-Y-N-P-Q-R-T	199.8	167,427
Antoine Creek/2L1	A-B-U-X-V-G-G1-G2-H1-H2-J-K-L-Y1-Y-N-P-Q-R-T	192.8	153,942
Bridge River	A-B-W-C-E-F1-X-V-G-G1-G2-H1-H-H2-J-K-L-Y1-Y-N-P-Q-R-T	199.8	154,355
Ore Creek	A-B-U-V-G-G1-G2-H1-H-H2-J-K-L-Y1-Y-N-P-Q-R-T	205.5	157,691

Table 9-2 Main Route Lengths and Costs

SUB-ROUTE OPTION	NODES	ADDITIONAL LENGTH km	ESTIMATED ADDITIONAL COST ($000)
Pavilion East	W-W1-D-E	0.6	1,926
Pavilion South	W-W1-F1	0.0	2,451
Pavilion Mid	C-D-E	0.0	396
Seton	G1-G2	0.5	1,493
D'Arcy	H1-H2	3.5	5,682
Birkenhead Lake	H-I-K	7.5	14,214
Ryan River	H-I-M-N1-N	23.5	48,318
Rainbow/2L1	L-M-N1-N	4.0	12,526
Rainbow/High Cheakamus	L-M-N1-Y2-Z-T	6.2	16,110
Function Junction	Y1-Y	0.3	307
High Cheakamus	Y-Y2-Z-T	2.1	2,449
Wountie	R-S-Z-T	1.5	1,781

Table 9-3 Sub-Route Option Lengths and Costs

10.0 RECOMMENDATIONS

10.1 RECOMMENDED ROUTE

Concluding from the technical studies summarized in this report, a route has been identified as the most economical, with an acceptable degree of anticipated line security. This route is identified as 5L42/2L1 in Table 9-2. Approximately 37 km of the 135 km of the existing 2L1 right-of-way is proposed to be used for the new line.

However, in conjunction with the environmental studies and public consultation program carried out concurrently with these technical studies, a route termed the *Generally Favoured* has been identified. This is the above identified route with the addition of the Function Junction and High Cheakamus sub-route options (see Table 9-3). This route is also technically satisfactory, has an allowable degree of anticipated line security, with only a 2% increase in cost. It is this route that is therefore recommended for this project. A brief summary describing this recommended route, shown in Drawing B-2 contained in Appendix A, is as follows:

km 0...19

The line would exit the south side of Kelly Lake Substation and follow on the east side of existing 500 kV lines 5L41 and 5L42 for approximately 18 km (existing 230 kV woodpole lines 2L90 and 2L91 are situated between 5L41 and 5L42 in this section). For this portion of the route the new line would be located on existing unoccupied right-of-way.

km 19...35

At the Pavilion Indian Reserve, the two existing 500 kV lines, 5L42 and 5L41 diverge. The recommended route leaves the existing unoccupied right-of-way adjacent to 5L41 and follows 5L42 across the Fraser River. The new line would continue to be located adjacent and parallel to the east side of 5L42 over the Camelsfoot Range. It would also be adjacent to 5L42 through the Bridge River Indian Reserve where the route crosses the Bridge River valley.

km 35...65

On the ascent of the north side of Mission Ridge, the recommended route is also adjacent to south side of existing line 5L42. After reaching a summit of over 1800 metres, the route descends the south side of Mission Ridge again parallel to 5L42. The Seton Indian Reserve is crossed in this section.

km 65...84

From Shalalth through to D'Arcy, the recommended route is located on the west side of Anderson Lake, on the existing right-of-way presently occupied by 2L1. 2L1 is the lowest (and closest to the shoreline), of the four lines located along Anderson Lake.

km 84...117

At D'Arcy the new line would leave the 2L1 right-of-way through the Nequatque Indian Reserve of the Anderson Lake Band and be located through a corner of the reserve adjacent to circuit 3L2 on the west slope of the valley. Continuing south through the Birken area, the recommended route leaves the existing lines and would be located high on the south side of the valley. It would then descend and parallel 5L42 above the south shore of Gates Lake. The recommended route continues to parallel 5L42 to the existing Creekside Capacitor Station just north of Pemberton. This alignment would by-pass the Lokla Indian Reserve.

Photo 44 Looking south over the Lillooet River valley at Pemberton.

km 117...121

Creekside Capacitor Station presently serves 5L42. It is intended that the proposed line would also connect to this station. It would be necessary to enlarge the station to accommodate the capacitors for the new line. This expansion would approximately double the size of the present site but would be within property currently owned by BC Hydro.

From Creekside Capacitor Station to the north side of the Lillooet River valley, the proposed line would again replace the removed 2L1 line on existing right-of-way. In this area close to Mosquito Lake, this available right-of-way is located between the two existing lines 5L42 and 2L2.

km 121...125

Across the Lillooet River valley at Pemberton, the new line would not utilize the 2L1 right-of-way in favour of an alignment parallel to 5L42 located further from the town centre. A cross over of 5L42 would be necessary should it be determined that the south side, rather than the north side, of 5L42 is the preferable location. The line would continue to parallel 5L42 over Signal Hill on the south side of the valley.

km 125...143

To avoid crossing over Nairn Falls, the proposed line would leave the 5L42 alignment. The route would stay high on the south side of the valley until just south of the Tisdall area where it would rejoin the 5L42 alignment. At approximately 7 km from Green Lake, a section of the 2L1 right-of-way would be used for the new line through to Green Lake.

km 143...150

The three existing lines are located on the south side of Green Lake. Two of these lines, 2L1 and 2L2, are presently situated low, close to the shoreline. It is intended that 2L1 would be removed, and the new line would be located higher, adjacent to 5L42.

Between Green and Alta Lakes, through the River of Golden Dreams area, the new line would replace 2L1 between 5L42 and 2L2.

km 150...155

On the west side of Alta Lake, 2L1 is located on a bench above 2L2 and 5L42. It is recommended that the new line follow this alignment for a short distance (2km), before deviating to a location that is somewhat more screened from view. The line would then return to the 2L1 right-of-way through Function Junction at the south end of Whistler.

km 155...195

The most economical route for the new line between Whistler and Cheekye determined in this, and previous studies, is one that essentially followed the 2L1 alignment. This location, although technically desirable, had a number of environmental and public concerns, namely:

- the line would have to cross Daisy Lake
- the line would be in close proximity to both Pinecrest and Black Tusk residential developments
- the alignment through the Cheakamus Canyon was a concern from a visual perspective
- the line would cross the North Vancouver Outdoor School
- the line traversed the Cheakamus Indian Reserve
- the line was in close proximity to further residential development through the Upper Cheakamus

These considerations provided the rationale to adopt the following High Cheakamus route.

From Function Junction, the line would cross Highway 99 and the gravel pit area. After crossing 5L42, the line would then ascend through the logged areas above the east side of Daisy Lake before descending and crossing Rubble Creek close to BC Hydro's Daisy Lake dam.

Photo 45 The Pavilion Indian Reserve. Note by-pass routing option.

From Rubble Creek the route would generally follow 5L42 above highway 99 across Brohm Ridge and into Cheekye Substation. Some short deviations from the 5L42 alignment in this section would minimize the visibility of the line from Highway 99.

10.2 ALTERNATIVES TO THE RECOMMENDED ROUTE

The following alternatives will be considered if difficulties are encountered in securing a right-of-way in certain segments of the recommended route.

10.2.1 EAST PAVILION (W-W1-D-E)

Immediately north of the Pavilion Indian Reserve, the proposed line would leave the existing right-of-way of 5L41, 5L42, 2L90 and 2L91. It would descend and cross Highway 12 north of the Pavilion village. The route would traverse the bench to the east of the reserve before descending and crossing 5L41, 2L90, and 2L91. Highway 12 would also again be crossed. The line then crosses the Fraser River (approximately 1.5 km south of the existing 5L42 crossing), and rejoins the recommended route and the 5L42 alignment.

10.2.2 BRIDGE RIVER (F1-X-V-G)

From the west side of the Fraser River, the route would leave the 5L42 alignment and make an ascent of the Camelsfoot Range via to top end of Lee Creek. It would then descend into the Bridge River valley, crossing Applespring Creek, and continue north-west to Antoine Creek at the western boundary of the Bridge River Indian Reserve. Here the route crosses the Bridge River and makes a gradual ascent of the north side of Mission Ridge. At the summit of Mission Ridge, the route rejoins the recommended route and 5L42.

10.2.3 SETON (G1-G2)

On the south side of Mission Ridge, rather than following 5L42 through the Seton Indian Reserve, this alternate route remains high and north of the reserve. It would rejoin the recommended route south of Whitecap Creek once past the west boundary of the reserve.

10.2.4 RAINBOW MOUNTAIN (L-M-N1-Y2)

Close to Tisdall Capacitor Station near the confluence of the Green River and Rutherford Creek, this route alternative leaves the recommended route and proceeds up the Soo River valley. The route then crosses via a narrow pass west of Rainbow Mountain into the Callaghan valley. The route traverses the south face of Mount Sproat before crossing the Cheakamus River, Highway 99, and the existing 2L2 and 5L42 lines and rejoining the recommended route west of Daisy Lake.

Photo 46 The west end of Seton Lake, B.C. Hydro's Bridge River Generating Station. Note 5L42 crossing the Seton Indian Reserve.

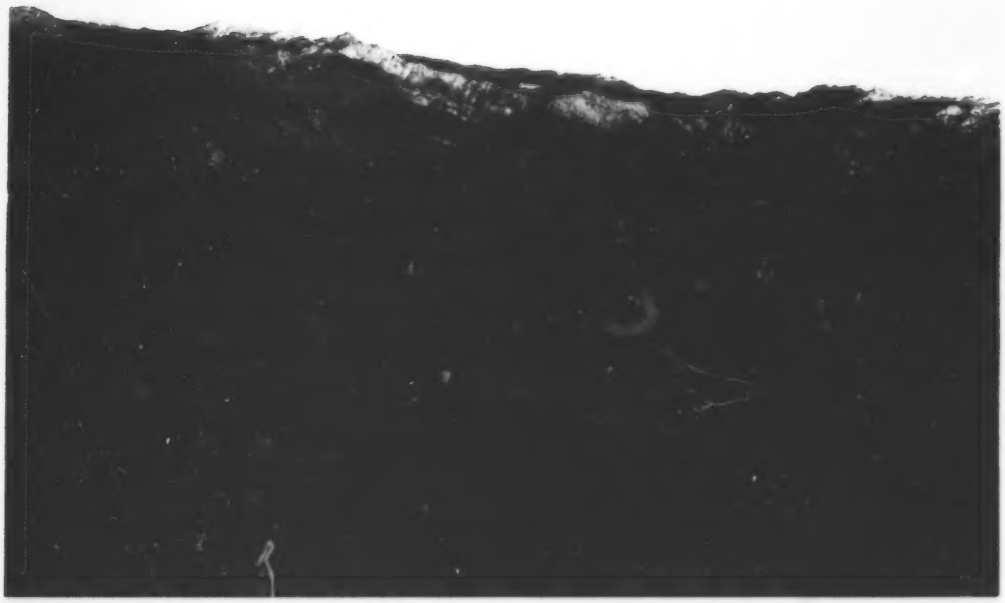

Photo 47 The Bridge River valley and route segment F'-X.

10.3 COST OF RECOMMENDED ROUTE

From Tables 9-2 and 9-3, the cost (exclusive of common costs as noted) of the recommended route is estimated to be **$145.5 million**. This is determined from a combination of the $142.7 million of the 5L42/2L1 route shown on Table 8-2, plus the $0.3 million of the Function Junction and the $2.5 million of the High Cheakamus sub-route options from Table 8-3. These costs do not include the cost of removing any of existing 230 kV transmission line 2L1 or any associated necessary substation work.

10.4 RECOMMENDED SURVEY SCHEDULE

The presently proposed project schedule indicates that field survey work commence in the fall of 1991. This is to ensure that all necessary survey and design work is completed in sufficient time to determine material quantities. This work would be restricted to survey control on Crown Land or existing rights-of-way.

As outlined in Section 4.0, the survey control is the establishment of vertical and horizontal coordinates of points along the proposed route preparatory to centreline survey.

The procedure for this survey work typically involves triangulation between these points on or near the transmission line centreline utilizing electronic measuring equipment. Line of sight is generally required to common prominent locations (such as mountain tops) between the points on centreline. A survey tag or hub is installed at each of the points along centreline. Minimal cutting of trees or vegetation is usually necessary with no cutting of centreline. In some cases, white cloth targets are installed for aerial identification purposes.

This control survey will be carried out over the entire proposed route plus any route alternatives still being considered. The work will also enable photogrammetric mapping to be produced which will assist in the evaluation of some of the more technically difficult and/or environmentally sensitive areas.

10.5 AREAS REQUIRING FURTHER STUDY

It is recognized that there are several areas where further detailed study is warranted to determine the most desirable alignment within the route segment. This further study was outside of the scope of this investigation and could only be carried out once a consensus on a proposed route was reached. The following sections outline these areas and the pertinent features of each.

10.5.1 PAVILION

The precise alignment through the Indian Reserve, the location of the necessary transmission line cross overs, and the tower locations for the Fraser River crossing all require further in depth review. Photogrammetric mapping will enable this investigation to be carried out without ground centreline survey. This mapping will also aid in determining and reducing the amount of clearing required.

Photo 48 The High Cheakamus route at Culliton Creek, looking north.

10.5.2 BRIDGE RIVER CROSSING

The steep slopes above the Fraser River immediately north of the Bridge River Indian Reserve (between segments F1-F) will require further detailed investigation to establish technically acceptable tower site locations. This will be accomplished by photogrammetric mapping and on site examination of potential sites. The mapping will enable tower locations to be identified without the need to carry out detailed ground survey (See Photos 1 and Photo 33).

10.5.3 SETON

South of Whitecap Creek, the proposed line crosses three existing lines. The relatively steep sideslope, and the potential of avalanche hazard, warrant detailed investigation to determine secure feasible crossing locations. Photogrammetric mapping would be used for this study.

10.5.4 BIRKEN/GATES

Considerable discussion and effort has gone into identifying a proposed route through this area. Public concern about the project has been high over the span of the project originating in the early 1980s. The presently recommended route has been selected with a view to minimize visual and land use impacts on the community. This area should also be photogrammetrically mapped to determine the most acceptable alignment relative to visibility and clearing requirements. Road construction would also be a major factor in the visibility of the line and mapping would enable more control over the road location and design.

10.5.5 BIRKENHEAD RIVER

Between Gates Lake and Creekside Capacitor Station, the Birkenhead River valley is narrow and steep sided. 2L1 is, for the most part, located either on the flood plain of the river or directly beside the highway. An alternative to utilizing the 2L1 right-of-way through this area is to locate the proposed line on the east side of the valley above 5L42. The technical difficulties and environmental consequences of this routing will be investigated further. Photogrammetric mapping would also be used in this investigation.

10.5.6 PEMBERTON

The precise alignment across the Lillooet River valley at Pemberton would require further investigation. The recommended route would parallel existing line 5L42. However it has yet to be determined on which side of 5L42 is best. Should the east side be favourable, the location of the transmission line crossover would have to be determined.

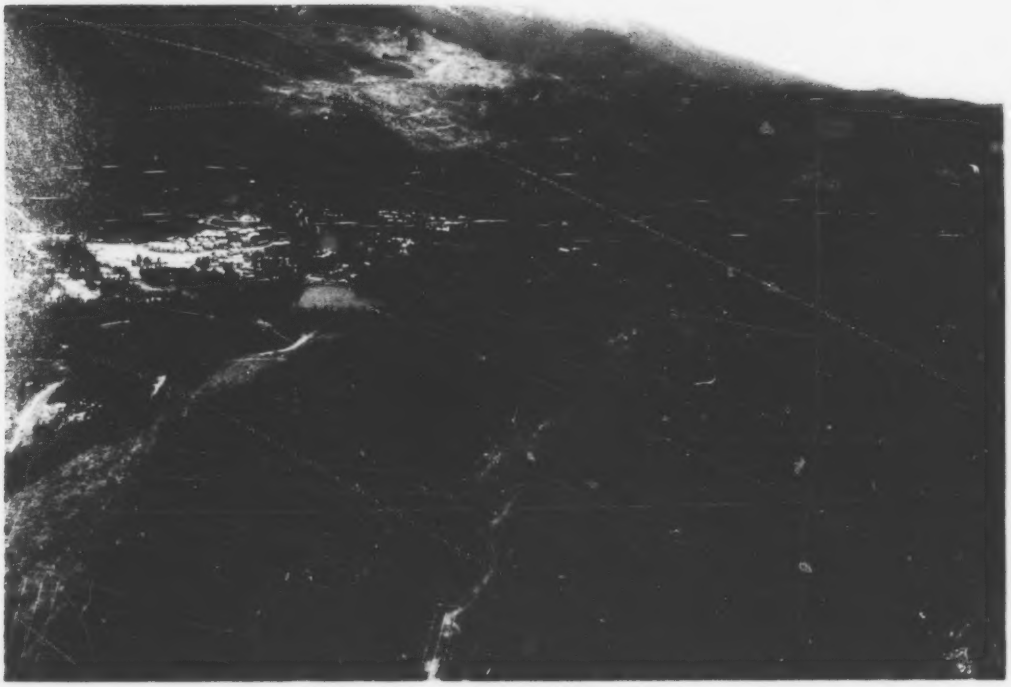

Photo 49 The west bench above Alta Lake at Whistler. Note the 2L1 right-of-way in centre of photo.

10.5.7 ALTA LAKE

The recommended location on the bench west of Alta Lake warrants further analysis to ensure that the optimum alignment is achieved. Both the visibility of the line and the technical difficulties associated with the crossing of 2L2 at the south end are significant issues. Also it is recognized that ultimately the existing lines 2L2 and 5L42 may, as a result of development expansion, be relocated to this higher bench. In view of this, the location of the new line must provide for possibility of this future relocation.

10.5.8 HIGH CHEAKAMUS

To ensure that the proposed line is screened from view to the greatest extent possible and to reduce the amount of clearing necessary, a more detailed review of this area would have to be undertaken. This again would involve the use of photogrammetric mapping.

10.6 SPECIAL CLEARING AND ACCESS CONSIDERATIONS

It is recognized that the visibility of this line is a major issue in some areas. It is acknowledged that the width of clearing is often a factor in the visibility of the line. To reduce this clearing width and subsequently the visibility of the line, it is intended that at least in selected areas, the clearing width be determined based on actual design conductor heights derived from detailed design rather than based on average assumed minimum conductor heights. These areas would include;

- Birken/Gates Lake
- Whistler
- Signal Hill (at Pemberton)

Schedule restrictions may limit the ability to use this method extensively on the project, but it is recommended to use it to the greatest degree possible, particularly in critical or sensitive areas traversed by the line.

The development of an access road network for the purpose of clearing, construction, and maintenance is a major component in the cost, appearance, and security of a transmission line route. It is for this reason that an access assessment for the recommended route is being prepared. Further detailed access requirements would be established once centreline survey and tower layout are completed. It is recognized that in many areas both the security and the long term appearance of the line are dependent on successful restoration of the construction access. This would involve the revegetation of the cut and fill slopes and stabilization of the roadbed to prevent any erosion problems.

It is intended that the location and design of roads be coordinated to accommodate the requirements of all of the activities requiring access on the right-of-way. This should eliminate the construction of numerous intertwined roads along the right-of-way characteristic of many of the older transmission lines in the province.

APPENDIX A
PINECREST ROUTE ALTERNATIVES

1.0 INTRODUCTION

As a result of discussions with private property owners and in response to a specific request, BC Hydro has investigated two further route alternatives between Whistler and Daisy Lake for the proposed second 500 kV transmission line between Kelly Lake and Cheekye Substations. These two alternatives are in addition to those routes investigated and included in Sections 6, 7, and 8 of the Technical Report.

Concern expresed by private property owners regarding the potential visibility of the proposed transmission line with respect to the Black Tusk initiated this request for further route investigations.

2.0 ROUTE DESCRIPTIONS

Similar to the route description methods used in Section 6 of the Technical Report, these new additional routes have been divided into segments delineated by node points. The subsequent route descriptions are also made with reference to Dwg No. 5L46-T07-X5M (sheet 3 of 9) included in Appendix B as were the routes described in Section 6.

2.1 HIGH CHEAKAMUS (Y1-Y-Y2-P1)

This is the route through this area recommended in the Technical Report. It consists of the Function West alternative together with the northern portion of the High Cheakamus segment. As noted in Section 6, there are existing roads throughout most of this route alternative that could provide much of the necessary transmission line construction access. There are no apparent security hazards along this route and, apart from a required crossing of 5L42 near Node Y, no technical difficulties are anticipated.

Preliminary review indicates that the line could be situated in a location such that the visibility of it would be minimal from the areas of concern. Further more detailed visual analysis has been undertaken.

2.2 PINECREST-HIGHWAY (Y1-N2-P1)

From Segment Node Y1, this route would generally follow the *uphill* side of the existing 2L2 right-of-way along the west side of Highway 99 to Node N2. In this area 2L1 and 2L2 are located along the western side of Highway 99. 2L1 is on the *downhill* side of 2L2. To avoid a double crossing of 2L2, and to locate 5L46 somewhat further away from Highway 99, the 2L1 right-of-way would not be used for the proposed line in this segment.

From Node N2 this route continues south on the west side of Highway 99. The route would climb to approximately the 825 metre elevation before descending behind a ridge west of the Pinecrest and Black Tusk developments.

Selecting a location to cross Highway 99 near Shadow Lake would be critical with respect to the visibility of the line. For the purpose of this investigation a crossing parallel to 5L42 was chosen. Other locations would be possible with little change in the technical analysis.

From the highway crossing, the route follows parallel to 5L42 until leaving it and rejoining the High Cheakamus route at Node P1.

South of Node N2 there is limited existing access into much of the portion of this route west of Highway 99. Some of the rocky areas in this section may have to be accessed by helicopter for construction purposes. There are no security hazards apparent.

2.3 PINECREST-5L42 (Y1-Y-N2-P1)

After the Function West segment through the Function Junction area south of Whistler, this route would follow the west side of 5L42 south approximately to Callaghan Creek. Here it would leave the 5L42 alignment and cross Callaghan Creek, the BCR, and Highway 99 and join the Pinecrest-Highway route at Node N2.

Existing logging roads into this area from could provide much of the necessary construction access. There are no apparent security hazards. The crossing of existing 2L2 near Highway 99 may be the only technical difficulty of the segment.

3.0 TECHNICAL EVALUATION

With reference to the introduction and description of the technical evaluation given in Section 7 of the Technical report, the following table summarizes the technical components of these additional route alternatives.

	SEGMENT NAME	NODE POINTS	TECHNICAL EVALUATION COMPONENTS			
			DESIGN	ACCESS	CLEARING	SPECIALIZED CONSTRUCTION
1	PINECREST	N2-P1	MEDIUM	HIGH	MEDIUM	LOW
2	CHEAKNORTH	Y-Y2	LOW	MODERATE	MEDIUM	LOW
3	HIGH CHEAK-NORTH	Y2-P1	MEDIUM	MEDIUM	MEDIUM	LOW
4	SPROAT	Y1-N2	MEDIUM	MEDIUM	MEDIUM	LOW
5	CALCHEAK	Y-N2	MODERATE	MODERATE	MODERATE	LOW
6	FUNCTION-WEST	Y1-Y	MODERATE	LOW	MODERATE	LOW

4.0 SECURITY EVALUATION

With reference to the introduction and description of the Security evaluation given in Section 8 of the Technical Report, the following table summarizes the security components of these additional route alternatives.

	SEGMENT NAME	NODE POINTS	HAZARD EVALUATION COMPONENTS			
			AVALANCHE	SLOPE FAILURE	RIVER EROSION	ICE LOADING
1	PINECREST	N2-P1	NIL	LOW	LOW	MEDIUM
2	CHEAKNORTH	Y-Y2	LOW	LOW	LOW	LOW
3	HIGH CHEAK-NORTH	Y2-P1	LOW	LOW	LOW	MEDIUM
4	SPROAT	Y1-N2	LOW	MEDIUM	LOW	LOW
5	CALCHEAK	Y-N2	NIL	LOW	LOW	LOW
6	FUNCTION-WEST	Y1-Y	NIL	LOW	LOW	LOW

5.0 TRANSMISSION LINE COST ANALYSIS

5.1 SEGMENT COSTS

With reference to the introduction and description of the Cost analysis given in Section 9 of the Technical Report, the following table summarizes the cost of these additional route segments.

	SEGMENT NAME	NODE POINTS	LENGTH km	ESTIMATED COST ($000)
1	PINECREST	N2-P1	14.5	10,800
2	CHEAKNORTH	Y-Y2	3.8	2,420
3	HIGH CHEAK-NORTH	Y2-P1	13.0	8,550
4	SPROAT	Y1-N2	8.5	5,390
5	CALCHEAK	Y-N2	5.0	2,804
6	FUNCTION-WEST	Y1-Y	3.3	1,970

5.2 ROUTE COSTS

The route costs resulting from these segments costs are summarized in the following table.

ROUTE	NODE POINTS	LENGTH km	ESTIMATED COST ($000)
HIGH CHEAKAMUS	Y1-Y-Y2-P1	20.1	12,950
PINECREST-HIGHWAY	Y1-N2-P1	23.0	16,189
PINECREST-5L42	Y1-Y-N2-P1	22.8	15,578

6.0 RECOMMENDATION

The routing originally proposed and recommended in the Technical Report is still preferred on a technical basis. Neither of the two alternate routes investigated offer any technical benefit over the original route. In addition the originally proposed route is 2.7 kilometres shorter and estimated to be approximately $2.6 million less expensive than the new Pinecrest-5L42 route alternative. Investigation from an environmental perspective will be carried out to determine the visual comparison of the various alternatives and the advantages, if any, of either.

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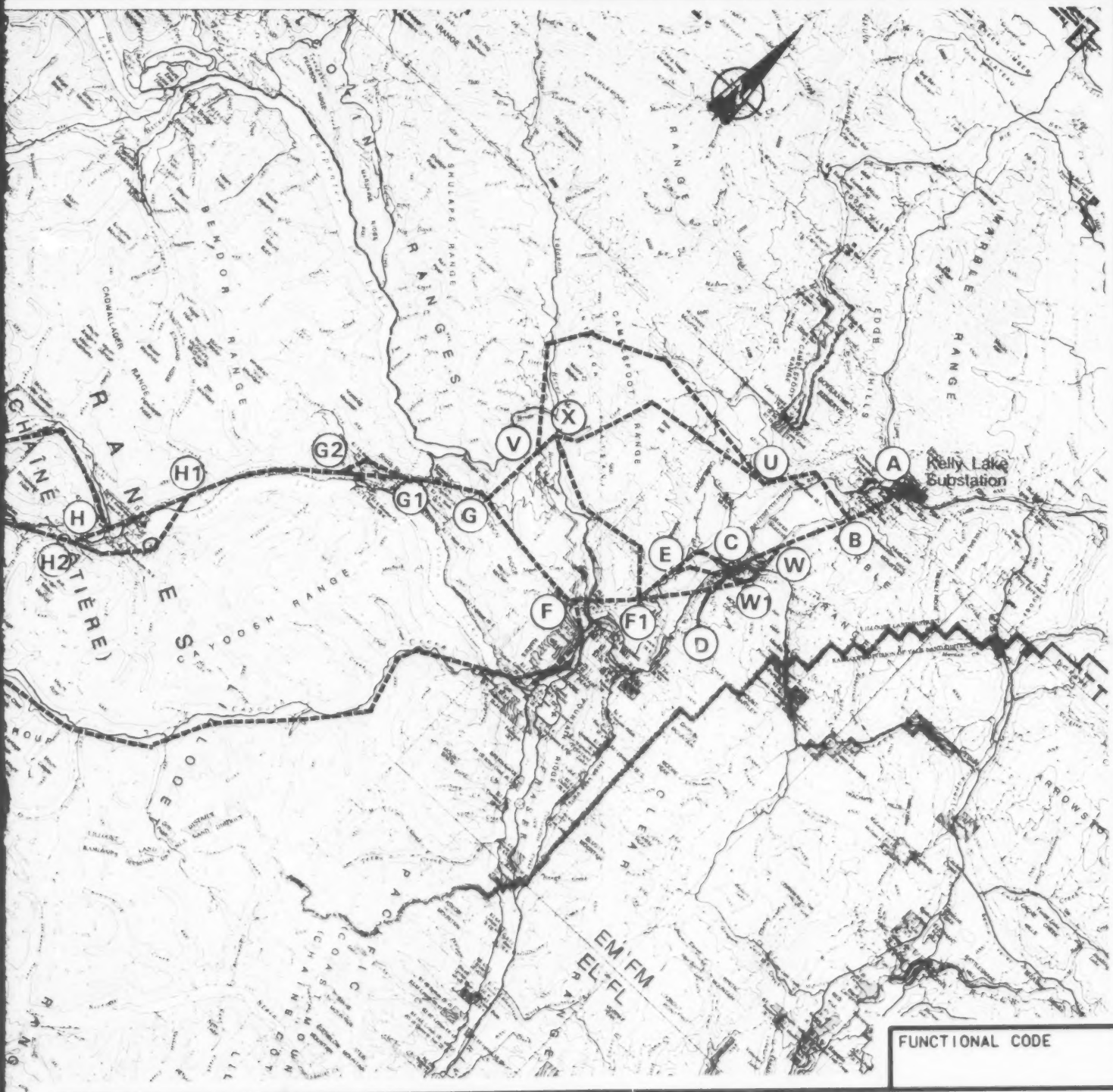
CHE	
APPR	

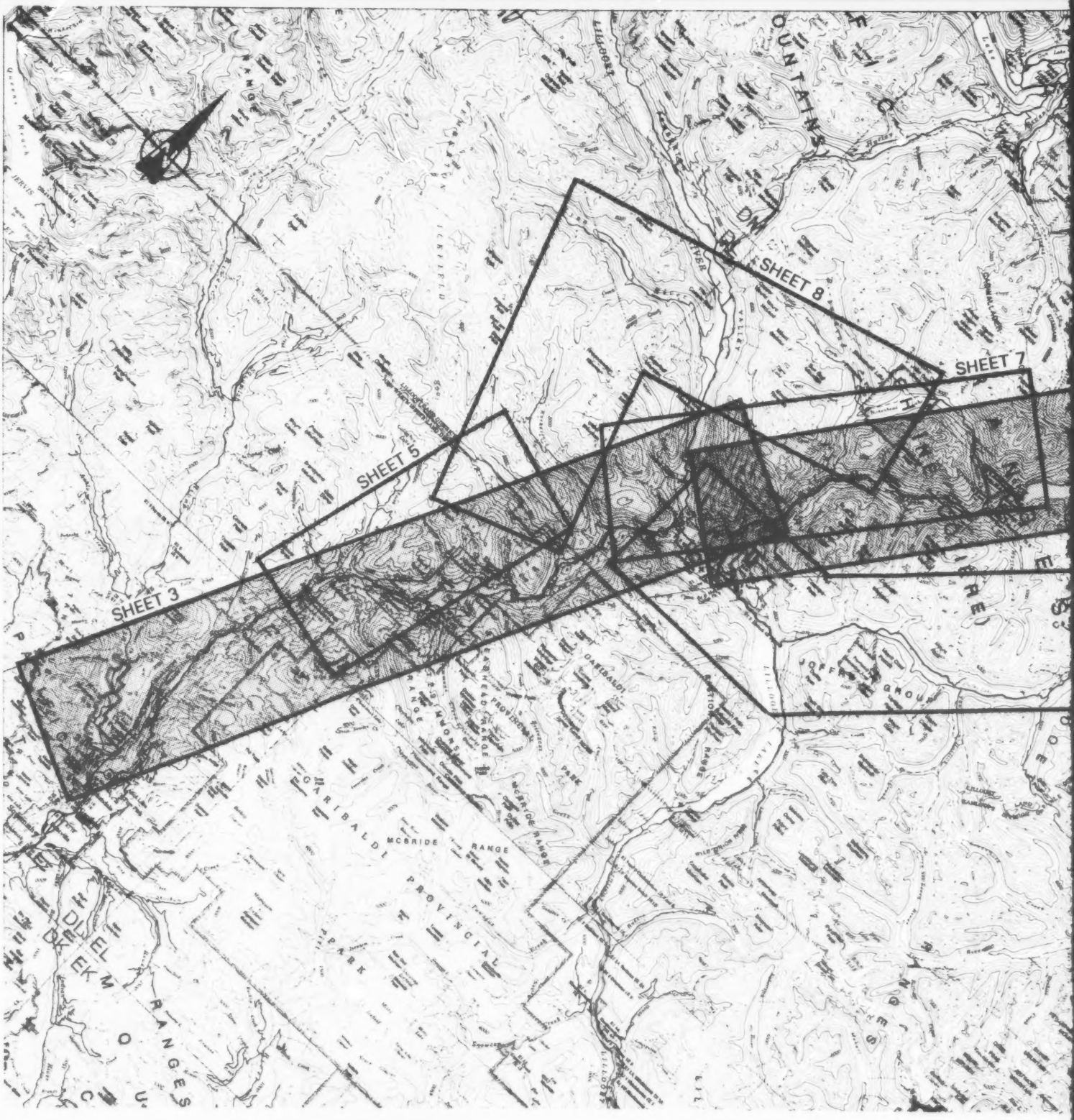
μ	No	REVISIONS	MADE	CHKD	SUBD	APPD	INSP	INSP	INSP	DATE

CAD FILE No.



FUNCTIONAL CODE

DESIGNED	SUBMITTED	SEAL	BC Hydro TRANSMISSION PROJECTS DIVISION
DRAWN	INSPECTED		KELLY LAKE - CHEEKYE 500 kV TRANSMISSION LINE **Route Alternatives and Node Points**
CHECKED DRAFTING	INSPECTED		
CHECKED DESIGN	INSPECTED		
APPROVED		DATE	SCALE 1:500,000 / μ / DWG. No **B-1** / R



CAD FILE No.

REFERENCE DRAWINGS	REFERENCE DRAWINGS	p	No.	REVISIONS	MADE	CHKD	SUBD	APPD	INSP	INSP	INSP	DATE	p	No.	REVI

FUNCTIONAL CODE

DESIGNED	SUBMITTED	SEAL	BC Hydro TRANSMISSION ENGINEERING DIVISION
DRAWN	INSPECTED		KELLY LAKE-CHEEKYE 500 kV TRANSMISSION LINE
CHECKED DRAFTING	INSPECTED		KEY PLAN OF ROUTE ALTERNATIVES
CHECKED DESIGN	INSPECTED		
APPROVED		DATE DEC 90	SCALE 1:500 000 DWG. No. 5L46-T07-B10 R

No.	REVISIONS	MADE	CHKD	SUBD	APPD	INSP	INSP	INSP	DATE

MATCH LINE TO SHEET 2

SETON LAKE

MATCH LINE TO SHEET 6

MISSION RIDGE

CHILCOTIN RANGES

RIDGE RIVER

CHILCOTIN RIVER

MATCH LINE TO SHEET 1

Pavilion-Clinton Rd

West Pavilion Rd

Pavilion Mtn Meadows

Kelly Lake

Kelly Lake Provincial Park

Milkranch Creek

Marka Creek

Indian Reserve

Pavilion Mountain Resort

Pavilion Mountain Lookout

Pavilion Mtn Meadows

Pavilion Mtn Resort

Pavilion Mtn Lookout

Pavilion Mtn Lookout Rd

Pavilion Mtn Resort Rd

Pavilion Mtn Lookout Trail

Pavilion Mtn Resort Trail

Kelly Lake Substation

Kelly Lake

Kelly Lake

B.C. RAIL

ROUND LAKE FARM

Leighland Lake

CANADIAN KELLY LAKE RD

Pavilion Mtn Microwave Rd

MATCH LINE TO SHEET A

Mount Carlson

Microwave Pavilion Mountain

T.S. LOOP SALT

Pavilion

Creek

Study Area

KEY PLAN

LEGEND

- Route alternative 500kV T/L Circuit 5L46 on new R/W
- Existing 500kV T/L Circuit 5L41
- Existing 500kV T/L Circuit 5L42
- Existing 230kV T/L Circuit 2L90 & 2L91

(Except from Kelly Lake to Node C, here Circuit 5L46 would utilize existing unoccupied R/W)

No.	REVISIONS	MADE	CHKD	SUBD	APPD	INSP	INSP	INSP	DATE
2	Routes Updated	JBB	RH						90-XI-16
1	ROUTE REVISED	TSB	RH						87-XII-4

DESIGNED	SUBMITTED	B.C. Hydro	
DRAWN	INSPECTED	TRANSMISSION ENGINEERING DIVISION	
CHECKED DRAFTING	INSPECTED	KELLY LAKE-CHEEKYE 500kV TRANSMISSION LINE (CIRCUIT 5L46)	
CHECKED DESIGN	INSPECTED	PLAN OF ROUTE ALTERNATIVES PAVILION	
APPROVED			
FUNCTIONAL CODE	DATE	SCALE 1:50000	DWG. No. 5L46-T07-X5M R2

MATCH LINE TO SHEET 3

COAST MOUNTAINS

CHILCOTIN RANGE

CHILLIWACK RANGE

PLACER MOUNTAIN

CALLOOKOOSE

B.C. RAIL

Pemberton Diesel Rd

Creekside Capacitor Station

Creekside

Spetch Creek

Owl Creek

Pemberton Creek

Pemberton Pass

Poole Creek

Gates Lake

Gates River

Sandbarrow Creek

Birkenhead River

Birkenhead Peak

Birken Glacier

Mount Currie

Mount Currie Indian Reserve

Mount Currie Indian Reserve

Mount Currie Indian Reserve

Mount Cheakamus

Mount Gee

Joffre Glacier

Gates Peak

Mount Gee

Mount Currie

Mount Currie Indian Reserve

Mount Currie Indian Reserve

Mount Currie Indian Reserve

MATCH LINE TO SHEET 7

H1

H2

Devine Substation

ANDERSON LAKE INDIAN RESERVE
RÉSERVE INDIENNE ANDERSON LAKE 5

Blackwater Creek

Hawkwarm Lake

Scout Creek

Birkenhead Peak

Birken Glacier

Gates River

Gates

Gates Creek

Gates Creek

Gates Creek

Mitc Creek

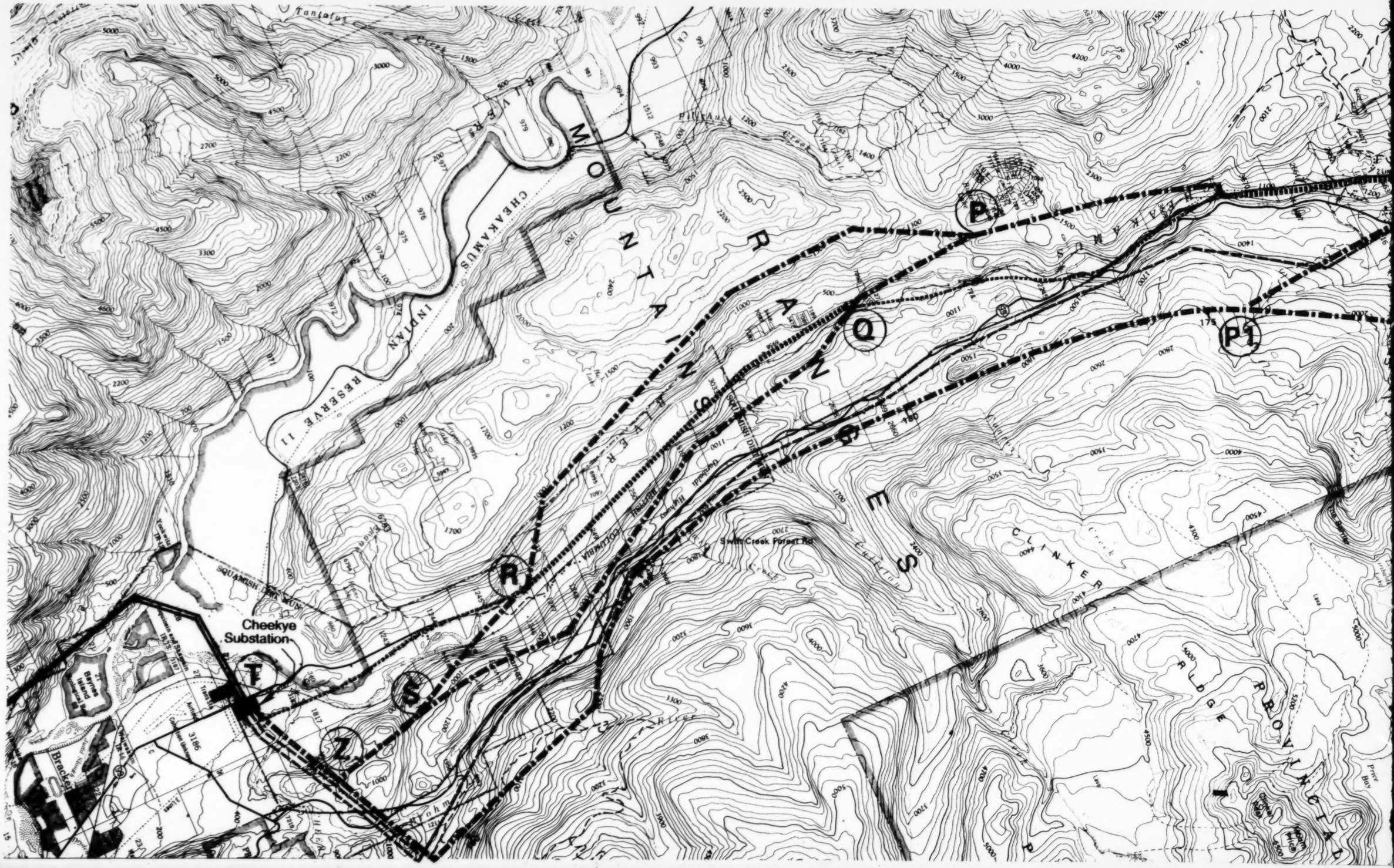
Spruce Creek

Spruce Creek

Spruce

Bridge River Terminal

LAKE
MATCH LINE TO SHEET 1
Skwath Forestry Dam Rd
G1
Bridge River Terminal
SLOSHI INDIAN RESERVE 14
SLOSHI INDIAN RESERVE
SLOSHI INDIAN RESERVE 14A
Former Nekliptkwa
South Shalalth
Former Nekliptkwa
Former Nekliptkwa
Former Nekliptkwa


MOUNTAINS
CHEAKAMUS
INDIAN RESERVE 11
Tantalus Creek
Cheekye Substation
Squamish River
Squamish-Pemberton Forest Rd
CLINKER RIDGE
PROVINCETIAD
Brackendale
Bayview Island
P
P1
Q
R
S
T

MATCH LINE TO SHEET 5

GARIBALDI PROVINCIAL PARK

GARIBALDI RIDGE

Daisy Lake

Brandywine Falls

Cheakamus

Emperium Ridge

Panorama Ridge

Black Tusk Meadows

Cinder Cone

Cinder Flats

Helm Ck

Helm Creek

Garibaldi

Fitzsimmons Range

Whistler Resort Municipality

Whistler Mountain

Blackcomb Mountain

Whistler Village

Alta Lake

Green Lake

Lost Lake

Nairn Falls

Function Junction

Cheakamus Lake Forest Rd

Tel-Cheak Rd

Callaghan Lake Forest Rd

Squamish-Lillooet Regional District

Resort Municipality of Whistler

Alpine Meadows

Emerald Estates

Rainbow

Nesters

Function

Green Lake

Alta Lake

Whistler

Blackcomb

Fitzsimmons

Range

Ridge

Creek

Lake

Glacier

Meadows

Cone

Flats

Falls

Village

Mountain

Municipality

Resort

Forest

Rd

Ch

Ck

Alm

Helm

Cinder

Black Tusk

Brandywine

Daisy

Cheakamus

Garibaldi

Emperium

Panorama

Fitzsimmons

Whistler

Blackcomb

Alta

Green

Lost

Nairn

Function

Rainbow

Nesters

Alpine

Meadows

Emerald

Estates

Squamish-Lillooet Regional District

Resort Municipality of Whistler

Tel-Cheak Rd

Callaghan Lake Forest Rd

Cheakamus Lake Forest Rd

N

N2

Y

Y1

Y2

P1

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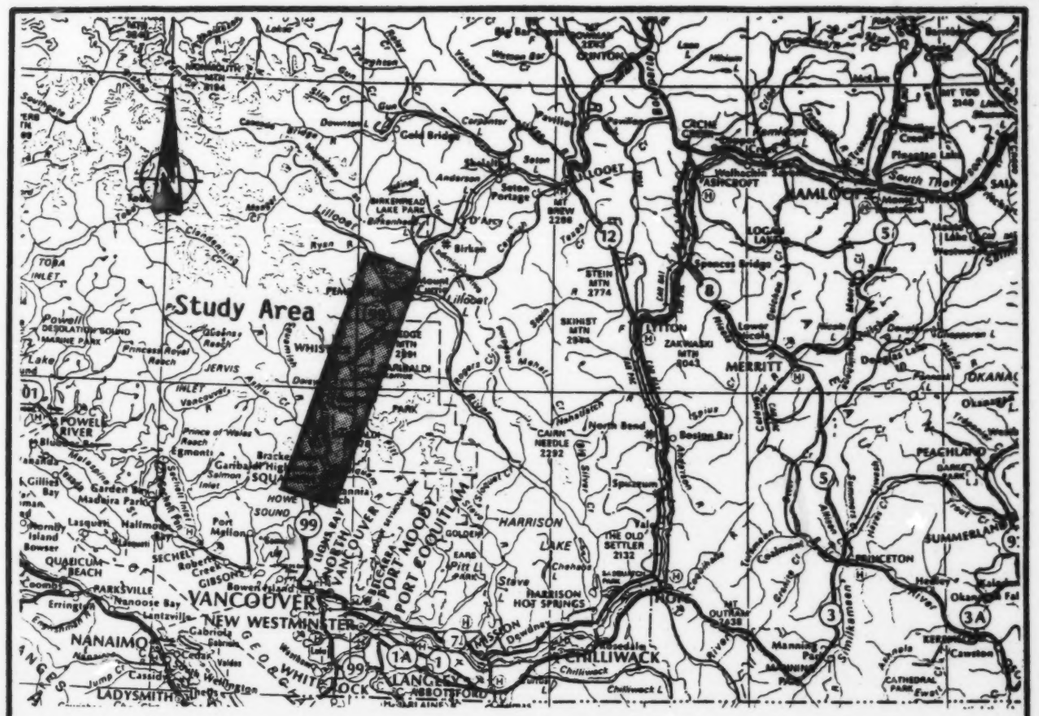
Rainbow Substation

Tisdall Capacitor Station



KEY PLAN

LEGEND

- Route alternative 500kV T/L Circuit 5L46 on new R/W
- Route alternative 500kV T/L Circuit 5L46 on existing R/W (2L1)
- Existing 500kV T/L Circuit 5L42 & 5L45
- Existing 500kV T/L Circuit 5L30 & 5L32
- Existing 360kV T/L Circuit 3L2
- Existing 230kV T/L Circuit 2L2
- Existing 230kV T/L Circuit 2L1 **(Right-of-way not utilized by 5L46)**

No.	REVISIONS	MADE	CHKD	SUBD	APPD	INSP	INSP	INSP	DATE
3	PINECREST ROUTES ADDED	PJ1							91-1-31
2	Routes Updated	JBB	PJ1						90-XI-16
1	ROUTE REVISED	TSB	PJ1						89-XII-4

DESIGNED	SUBMITTED
DRAWN	INSPECTED
CHECKED DRAFTING	INSPECTED
CHECKED DESIGN	INSPECTED
APPROVED	
FUNCTIONAL CODE	DATE 91-09-14

BC Hydro
TRANSMISSION ENGINEERING DIVISION

KELLY LAKE-CHEEKYE
500kV TRANSMISSION LINE (CIRCUIT 5L46)

PLAN OF ROUTE ALTERNATIVES
WHISTLER

SCALE 1:50000 | DWG. No. 5L46-T07-X5M | R3

MATCH LINE TO SHEET 2

MATCH LINE TO SHEET 3

LAKE

MISSION

SLOSH INDIAN RESERVE 1A

SLOSH INDIAN RESERVE 1

South Shalalth

Power House

Pumping Station

Pumphouse

Wharf

Campsite

Trail

Creek

Cairn

Pipeline

Pit

Quarry

Cut

Fill

Tunnel

Ruins

Mine

Adit

Shaft

Tailings

Dump

Gravel

Sand

Rock

Cliff

Bluff

Ridge

Spur

Saddle

Gully

Slide

Swamp

Marsh

Muskeg

Timber

Brush

Orchard

Vineyard

Fence

Gate

Bridge

Ford

Ferry

Cable

Telephone

Power Line

Pole

Tower

Building

Church

School

Hall

Store

Post Office

Hotel

Cemetery

Monument

Boundary

Reserve

Township

Section

Quarter

Lot

Block

Plan

Survey

Control

Bench Mark

Triangulation

Spot Height

Contour

Index

Scale

Datum

Projection

Grid

Zone

Meridian

Parallel

Origin

False Easting

False Northing

Central Meridian

Latitude

Longitude

Elevation

Depression

Hachures

Shading

Hill

Valley

Plateau

Terrace

Escarpment

Cliff

Bluff

Ridge

Spur

Saddle

Gully

Slide

Swamp

Marsh

Muskeg

Timber

Brush

Orchard

Vineyard

Fence

Gate

Bridge

Ford

Ferry

Cable

Telephone

Power Line

Pole

Tower

Building

Church

School

Hall

Store

Post Office

Hotel

Cemetery

Monument

Boundary

Reserve

Township

Section

Quarter

Lot

Block

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Survey

Control

Bench Mark

Triangulation

Spot Height

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Scale

Datum

Projection

Grid

Zone

Meridian

Parallel

Origin

False Easting

False Northing

Central Meridian

Latitude

Longitude

Elevation

Depression

Hachures

Shading

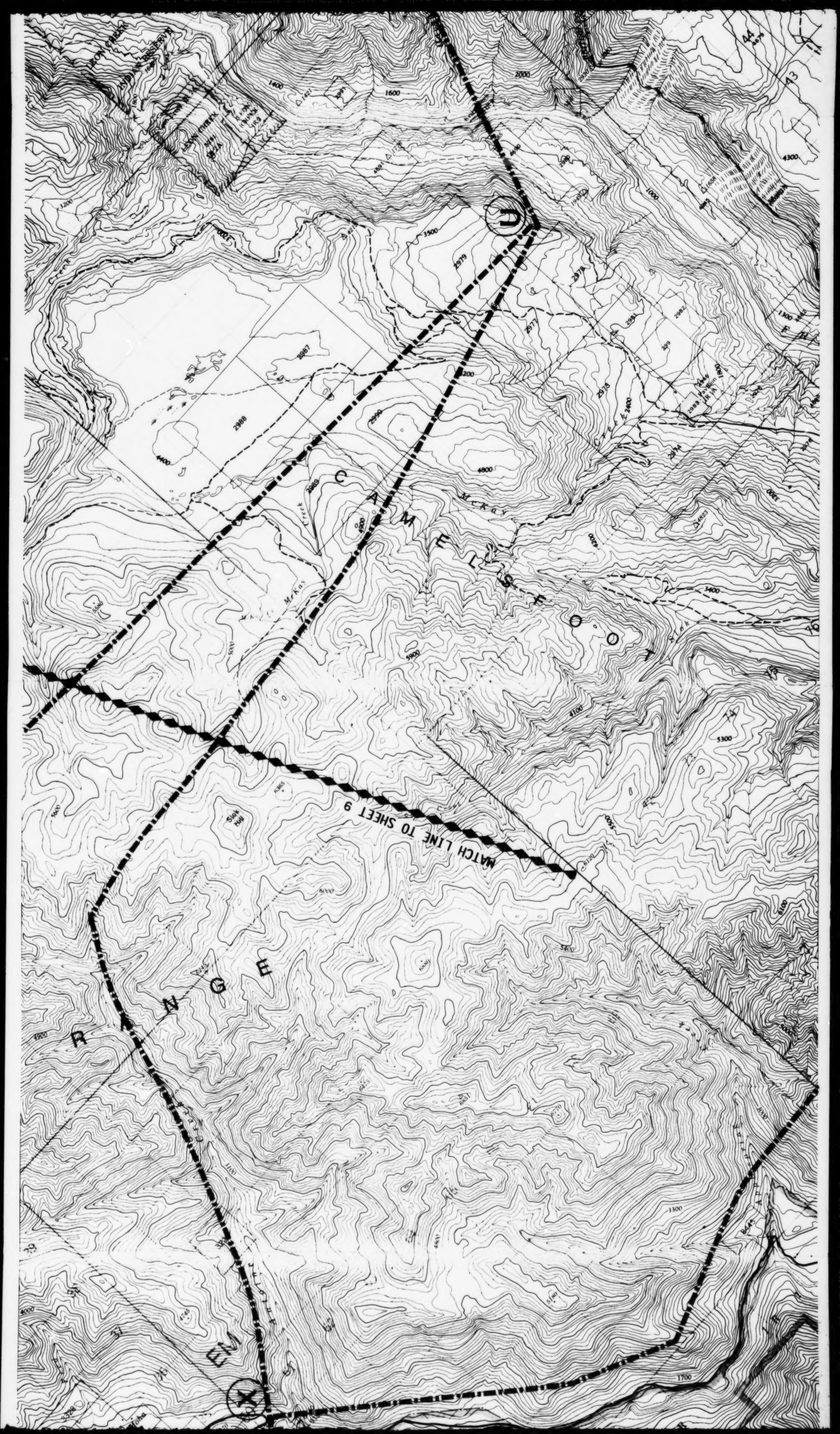
Hill

Valley

Plateau

Terrace

Escarpment


CAMELSFOOT
RANGE
MATCH LINE TO SHEET 9

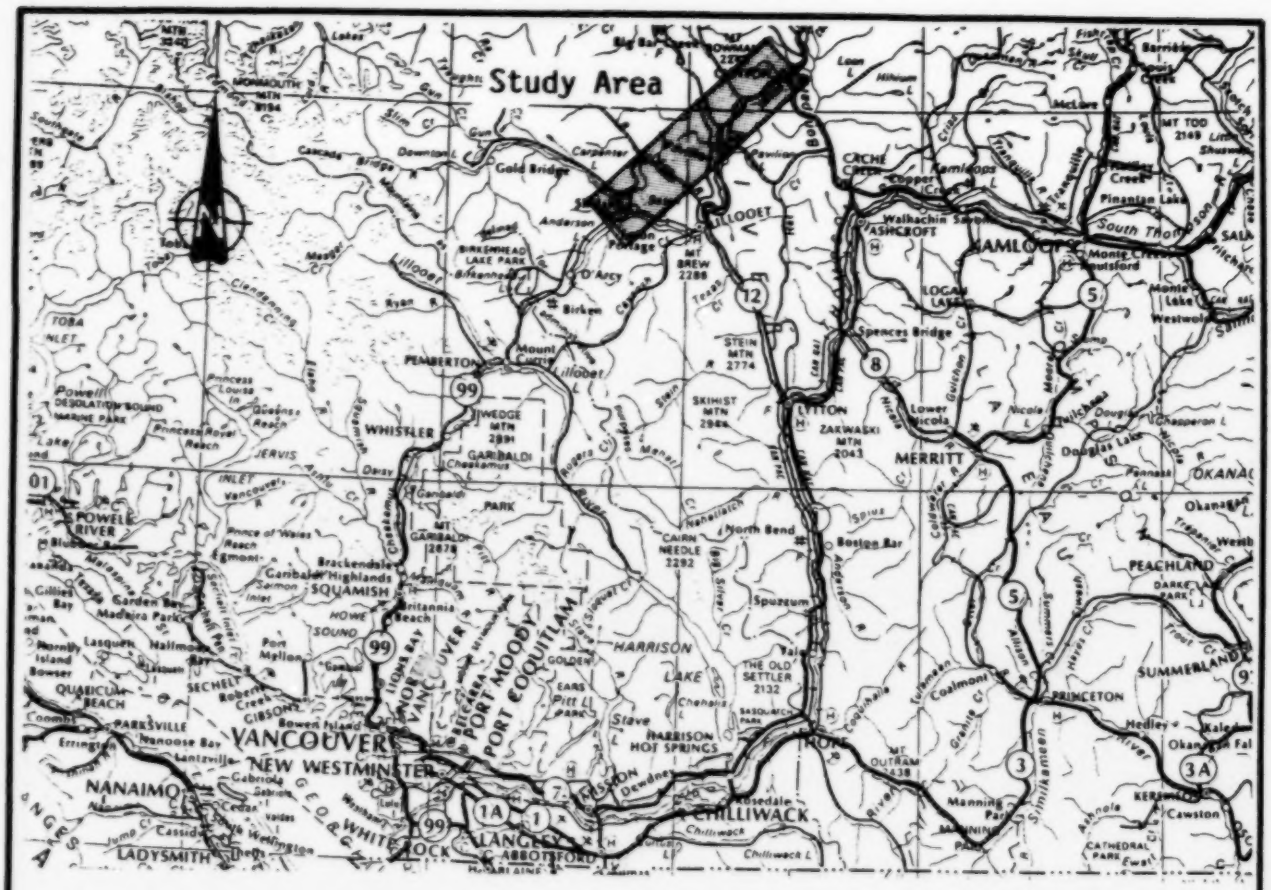
MATCH LINE TO SHEET 1

Kelly Lake Substation

U

B

P



KEY PLAN

LEGEND

- Route alternative 500kV T/L Circuit 5L46 on new R/W
- Route alternative 500kV T/L Circuit 5L46 on existing R/W
- Existing 500kV T/L Circuit 5L41
- Existing 500kV T/L Circuit 5L42
- Existing 360kV T/L Circuit 3L2
- Existing 230kV T/L Circuit 2L90 & 2L91
- Existing 230kV T/L Circuit 2L2
- Existing 230kV T/L Circuit 2L1

μ	No.	REVISIONS	MADE	CHKD	SUBD	APPD	INSP	INSP	INSP	DATE
	1	Routes Updated	JBB							90-11-16

DESIGNED	SUBMITTED	⊕ BC Hydro	
DRAWN	INSPECTED	TRANSMISSION ENGINEERING DIVISION	
CHECKED DRAFTING	INSPECTED	KELLY LAKE-CHEEKYE 500kV TRANSMISSION LINE (CIRCUIT 5L46)	
CHECKED DESIGN	INSPECTED	**PLAN OF ROUTE ALTERNATIVES**	
APPROVED		ANTOINE CREEK	
FUNCTIONAL CODE	DATE	SCALE 1:50000	DWG. No. 5L46-T07-X5M R1

MATCH LINE TO SHEET 3
GARIBALDI
PROVINCIAL PARK
Whistler Resort Municipality
FITZSIMMONS
RANGE
BRITISH COLUMBIA
Cheakamus
Brandywine Falls
BRANDYWINE FALLS
PROVINCIAL PARK
Squire
TL 8100
TL 8101
TL 8084
TL 8088
TL 8092
TL 8096
TL 8098
TL 8099
TL 8104
TL 8108
TL 8089
TL 8093
TL 8094
TL 8090
TL 8060
N1
N2
Y
Z
50
49
48
47
46
45
44
43
42

MATCH LINE TO SHEET 8

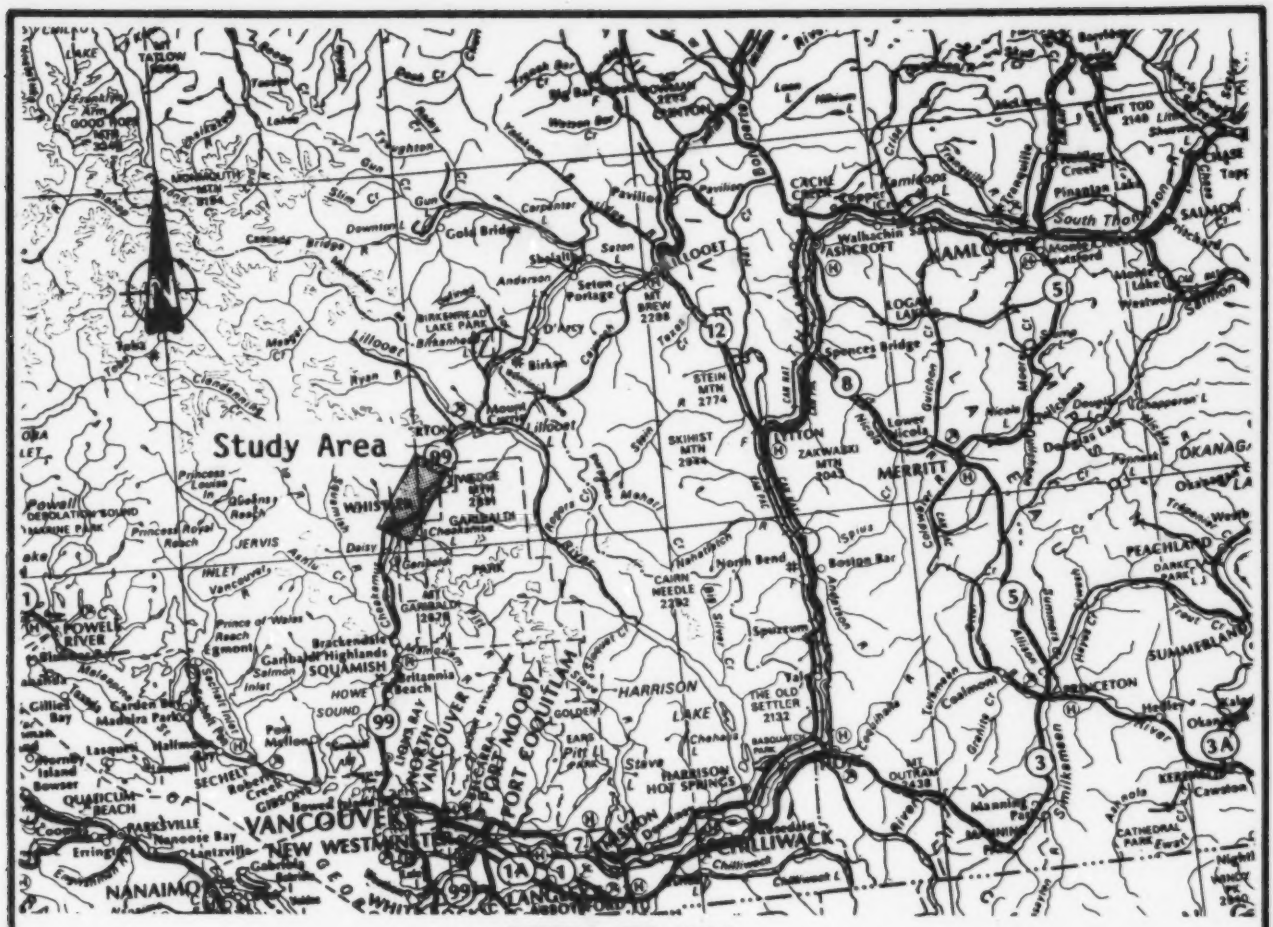
MATCH LINE TO SHEET 7

LEGEN

2 PINE

	1	Rou
M.	No.	
DESIGNED		
DRAWN		
CHECKED DRAFT		
CHECKED DESIG		
APPROVED		
		FUNCTION

CAD FILE No.



KEY PLAN

LEGEND

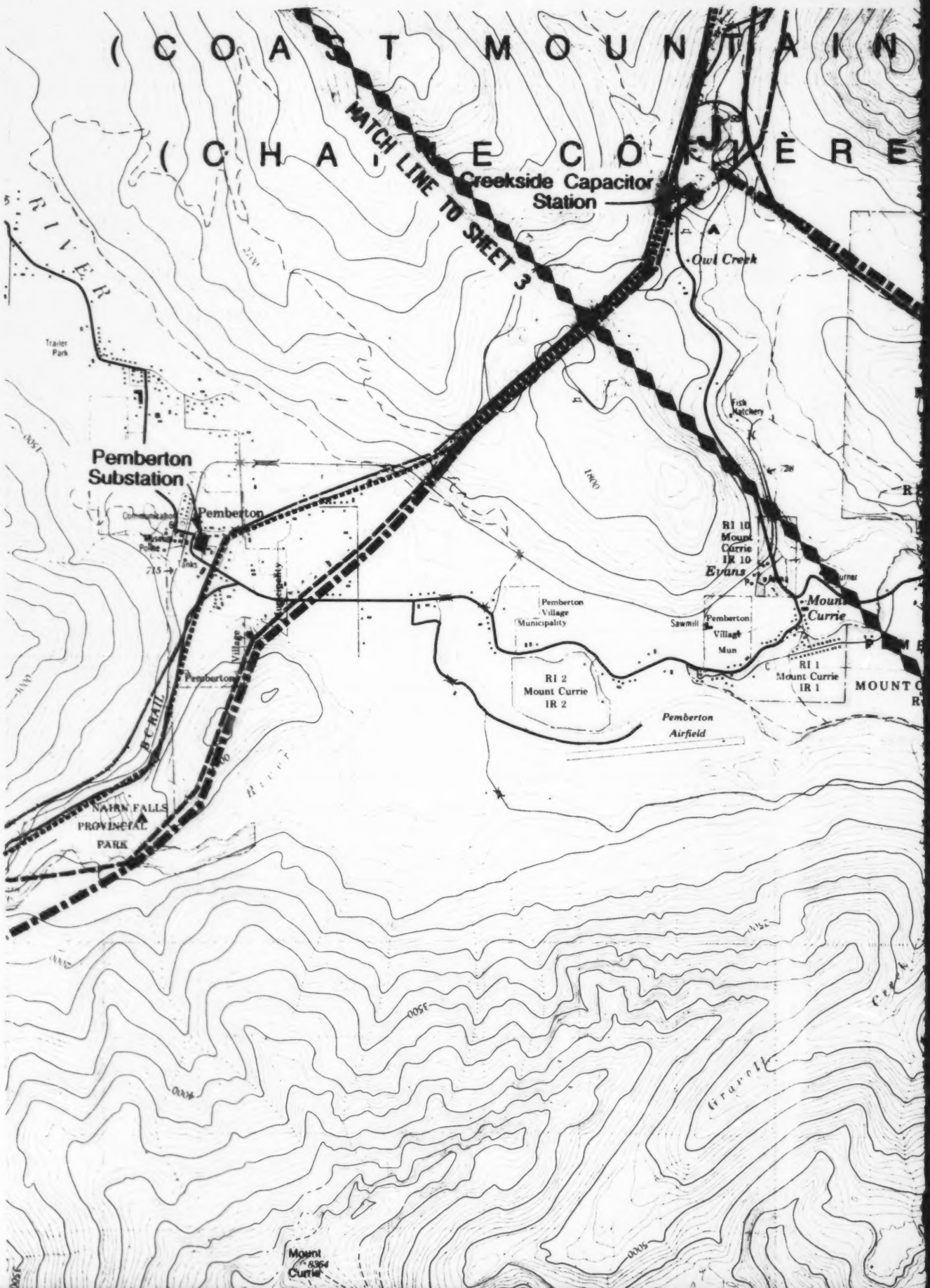
- Route alternative 500kV T/L Circuit 5L46 on new R/W
- Existing 500kV T/L Circuit 5L42
- Existing 230kV T/L Circuit 2L2
- Existing 230kV T/L Circuit 2L1

2 PINECREST ROUTES ADDED RJH 91-1

	No.	REVISIONS	MADE	CHKD	SUBD	APPD	INSP	INSP	INSP	DATE
	1	Routes Updated	JBB	RJH		JL				90 XI 16

DESIGNED RJH	SUBMITTED	B.C. Hydro	
DRAWN RJH	INSPECTED	TRANSMISSION ENGINEERING DIVISION	
CHECKED DRAFTING	INSPECTED	KELLY LAKE-CHEEKYE 500kV TRANSMISSION LINE (CIRCUIT 5L46)	
CHECKED DESIGN	INSPECTED	PLAN OF ROUTE ALTERNATIVES	
APPROVED		RAINBOW MOUNTAIN	
FUNCTIONAL CODE	DATE 89-09-14	SCALE 1:50000	DWG. No. 5L46 - T07 - X5M R-

CAD FILE No.


(COAST MOUNTAIN
(CHAÎNE CÔTIÈRE
MATCH LINE TO SHEET 3
Creekside Capacitor Station
Owl Creek
Pemberton Substation
Pemberton
Trailer Park
Fish Hatchery
RI 10 Mount Currie IR 10
Evans
Mount Currie
Pemberton Village Municipality
Sawmill
Pemberton Village Mun
RI 2 Mount Currie IR 2
RI 1 Mount Currie IR 1
Pemberton Airfield
B.C. Rail
NAIRN FALLS PROVINCIAL PARK
Gravel
Mount Currie
8364

MATCH LINE

MATCH LINE

R G R O U P

ANGE S

G E

JOFFRE GROUP

JOFFRE

LILLOOET LAKE

BASTION RANGE

CAYOOSH PASS

Cayoosh Mountain

Duffey Lake

Cayoosh Creek

Joffre Creek

Two Goat Ridge

Duffey Peak

Mount Taylor

Tzeil Mountain

Black Mountain

Matier Glacier

Mount Sloan

Mount Matier

Mount Hurley

Mount Hurtzell

Hurtzell Glacier

Anniversary Glacier

Twin One Glacier

Mount Kenyon

Mount Chief Pascall

Joffre Peak

Middle Joffre Lake

Upper Joffre Lake

Joffre Creek

Carpenter Creek

Cayoosh Creek

Marlatt Creek

McClinton Creek

Cartline Creek

Cartline Ck

Twin C

6500

5500

4000

1000

CAYOOSH RANGE

Haylmore

BARKLEY VALLEY

Elliott Creek

Cayoosh Creek

Spruce Creek

Mount Rohr

Duffy Lake Rd

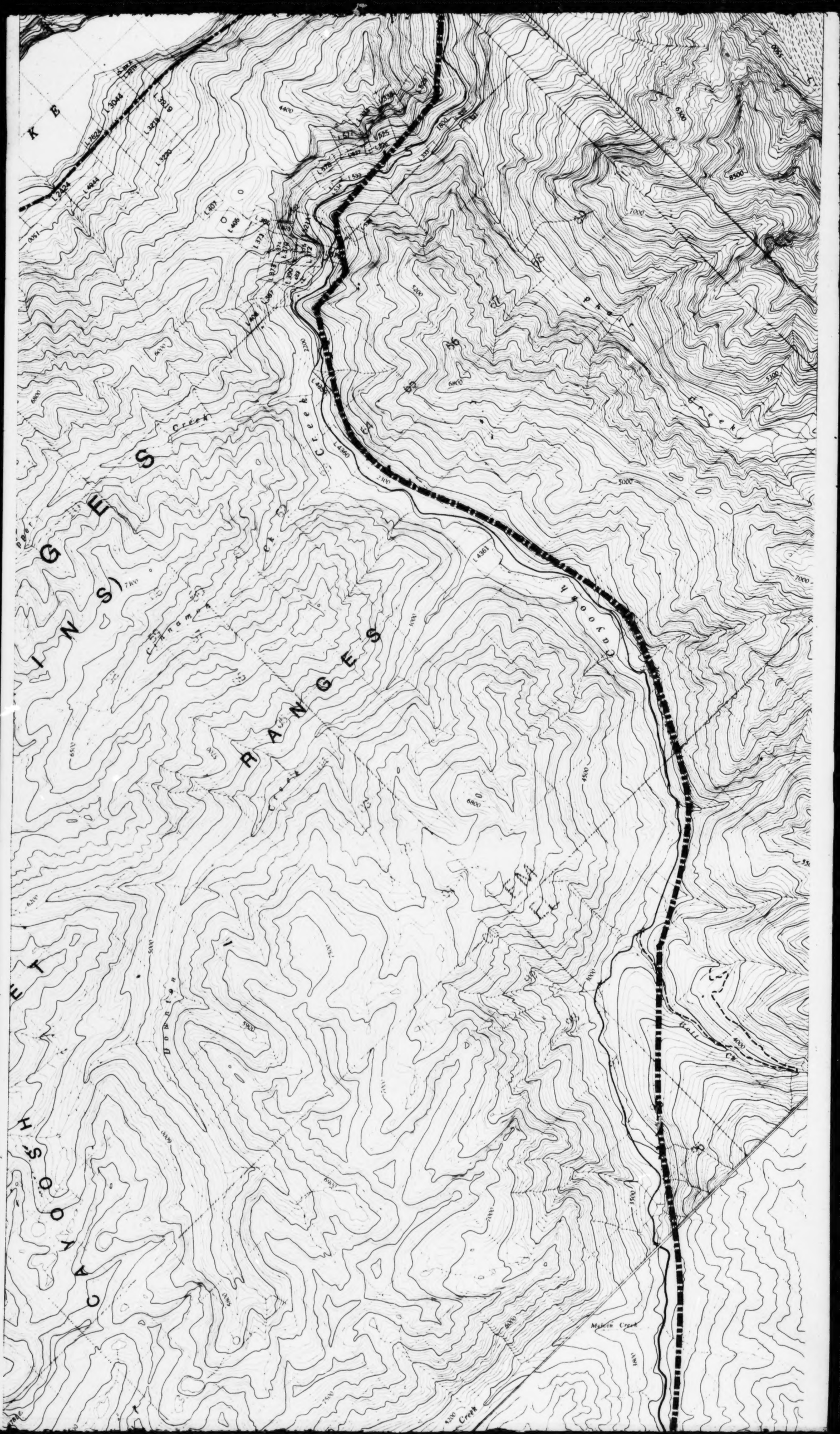
DUFFEY LAKE

Melvin Creek

Cayoosh Creek

Creek

Creek


SIERRA NEVADA
RANGES
Creek
Canyon
Trail
Melvin Creek

MATCH LINE TO SHEET 1

MATCH LINE TO SHEET 3

MATCH LINE TO SHEET 1

MATCH LINE TO SHEET 3

CAD FILE No.

LEG

No.

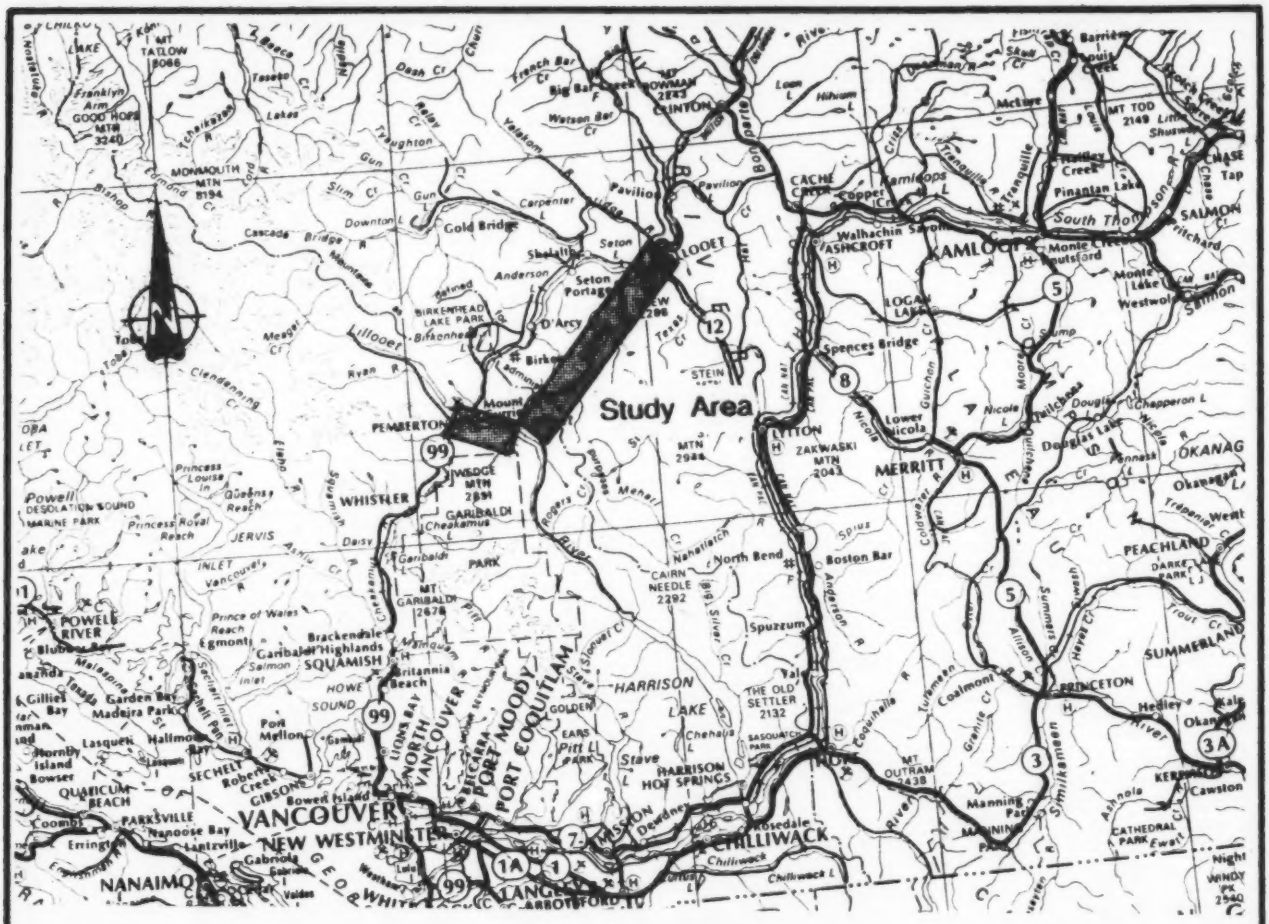
DESIGNED

DRAWN

CHECKED

CHECKED

APPROVED



KEY PLAN

LEGEND

- Route alternative 500kV T/L Circuit 5L46 on new R/W
- Route alternative 500kV T/L Circuit 5L46 on existing R/W
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- Existing 500kV T/L Circuit 5L42
- Existing 360kV T/L Circuit 3L2
- Existing 230kV T/L Circuit 2L90 & 2L91
- Existing 230kV T/L Circuit 2L2
- Existing 230kV T/L Circuit 2L1

μ	No.	REVISIONS	MADE	CHKD	SUBD	APPD	INSP	INSP	INSP	DATE
	1	Routes Updated	JBB							90-11-16

DESIGNED	SUBMITTED
DRAWN	INSPECTED
CHECKED DRAFTING	INSPECTED
CHECKED DESIGN	INSPECTED
APPROVED	

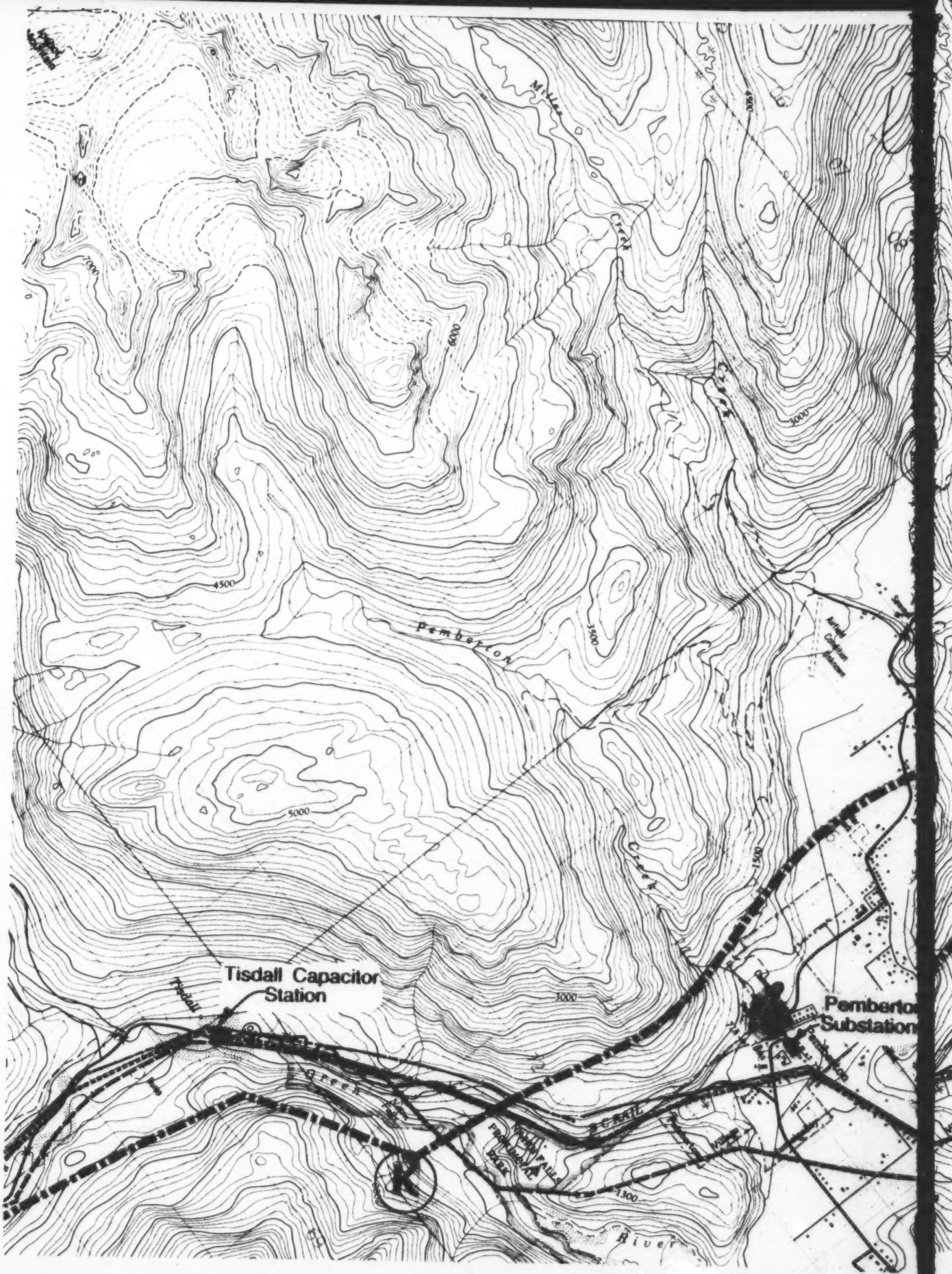
BC Hydro
TRANSMISSION ENGINEERING DIVISION

KELLY LAKE-CHEEKYE
500kV TRANSMISSION LINE (CIRCUIT 5L46)

PLAN OF ROUTE ALTERNATIVES

DUFFEY LAKE

CAD FILE No.	FUNCTIONAL CODE	DATE	SCALE	DWG. No.	R
	L.	87-9-14	1:50000	5L46 - T07 - X5M	1


Tisdall Capacitor Station
Pemberton
Substation
Pemberton
Creek
Green
River
7000
6000
5000
4500
3500
2000
1500
1000
1300

MATCH LINE TO SHEET 3

MATCH LINE TO SHEET 5

PACIFIC RANGES

COAST MOUNTAINS

COAST MOUNTAINS

LILLOOET VALLEY

Lillooet River

Owl Lake

Fowl Creek

Tenas Creek

Tenas Lake

Tailholt Creek

Pemberton Substation

Creekside Capacitor Station

B.C. RAIL

Poole

Gates Lake

Birkenhead Lake

Mt. Keating

Mount Currie

BIRKENHEAD PROVINCIAL PARK

Birkenhead Lake

Tail Creek

Powder Creek

Glacier

Birkenhead Peak

Gates Lake

Gates River

Scout Creek

Blackwater Creek

ANDERSON LAKE INDIAN RESERVE
RÉSERVE INDIENNE
ANDERSON LAKE 8

MATCH LINE TO SHEET 2

Lajoie Substation

SQUAMISH

Study Area

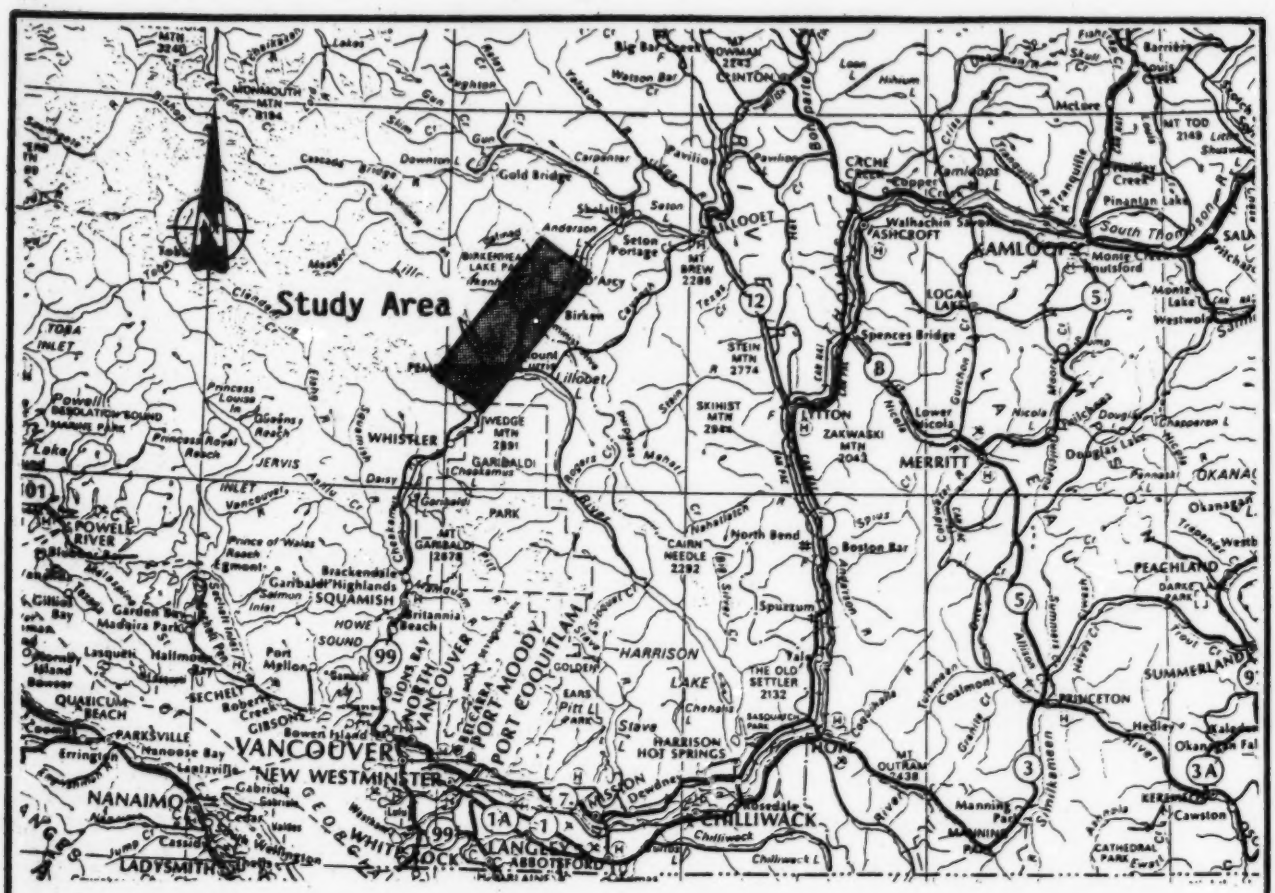
KEY P

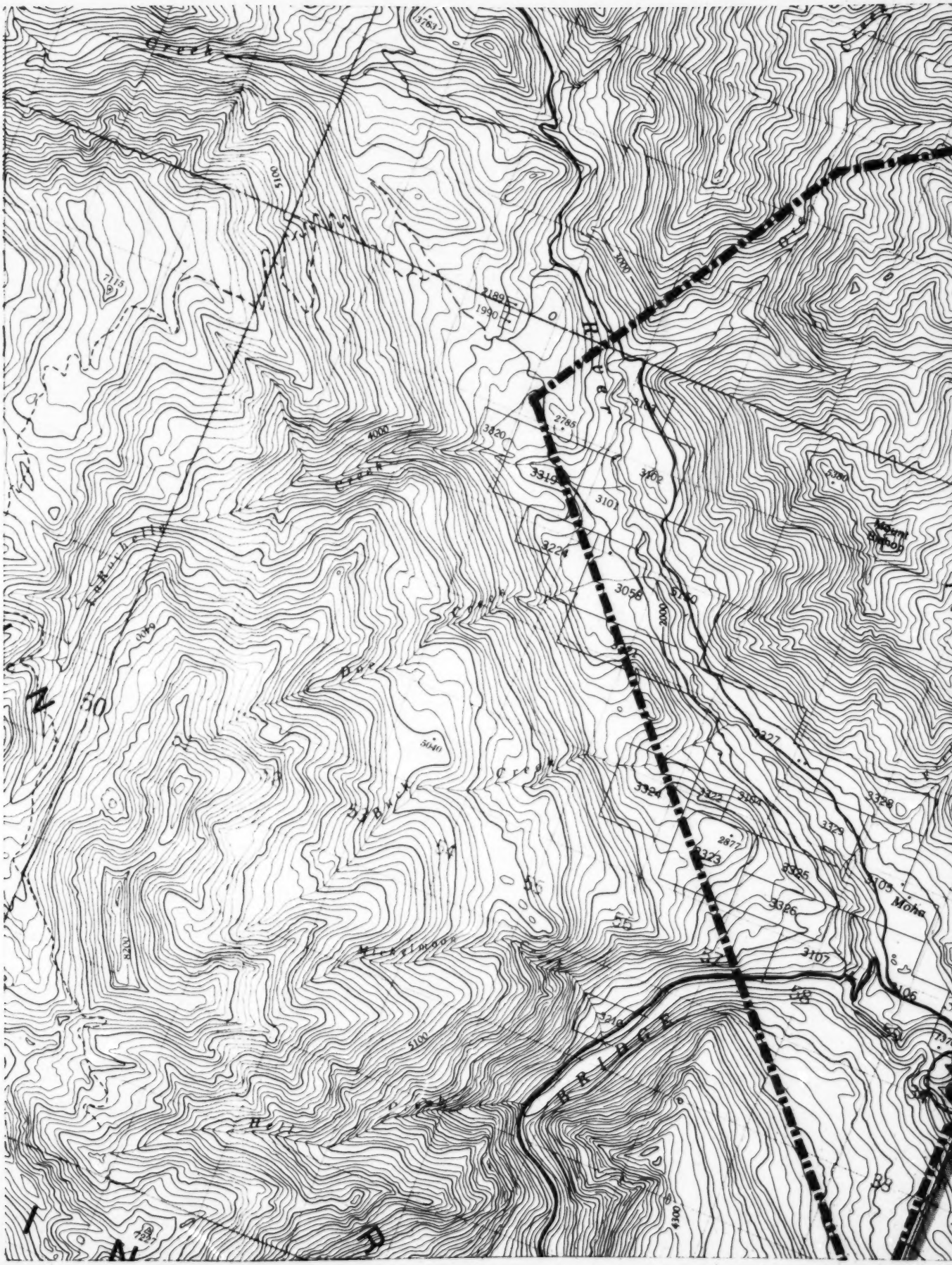
LEGEND

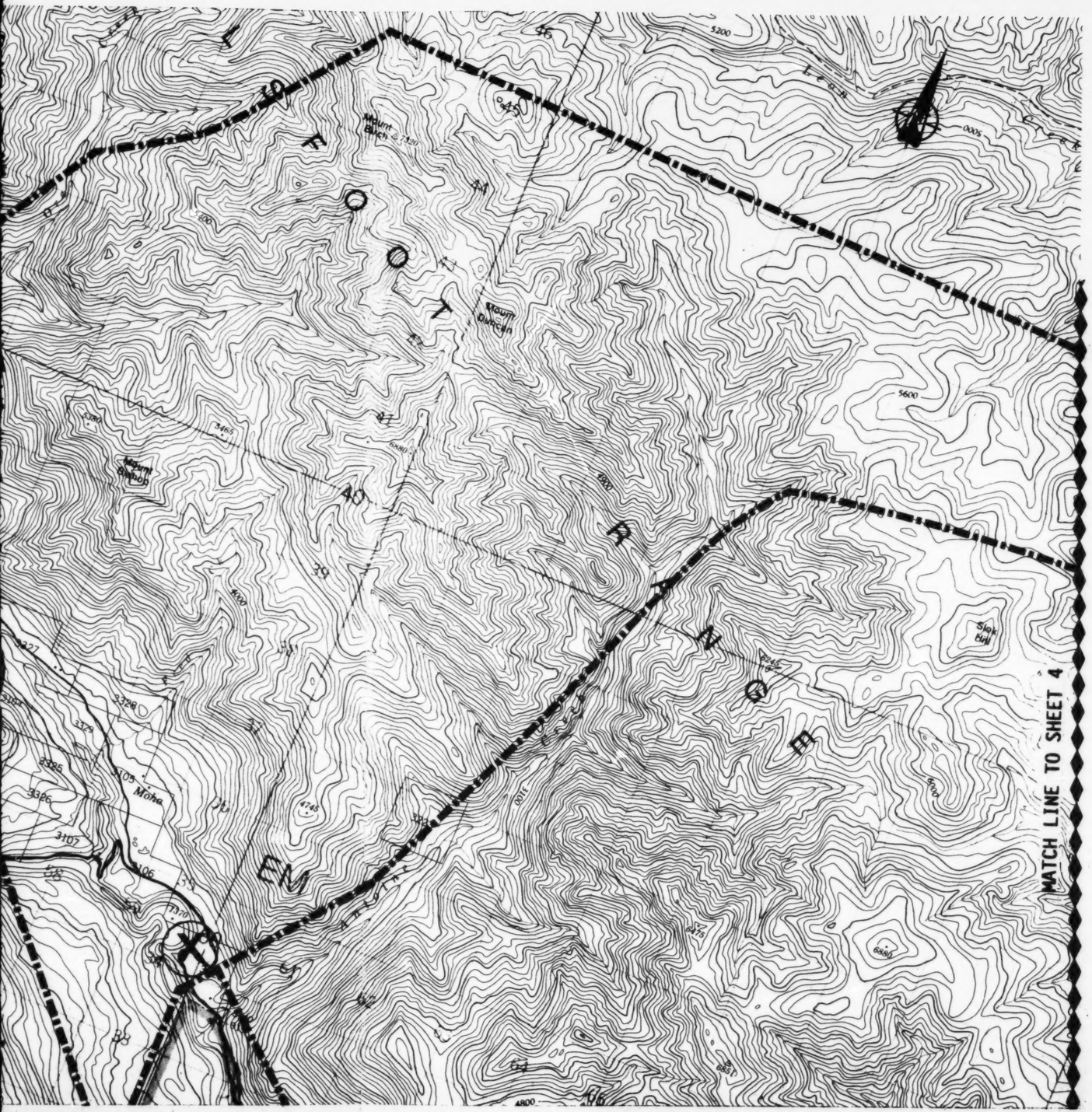
- Route alternative 500kV T/L Circuit 5L46
- Route alternative 500kV T/L Circuit 5L46
- Existing 500kV T/L Circuit 5L42
- Existing 360kV T/L Circuit 3L2
- Existing 230kV T/L Circuit 2L2
- Existing 230kV T/L Circuit 2L1

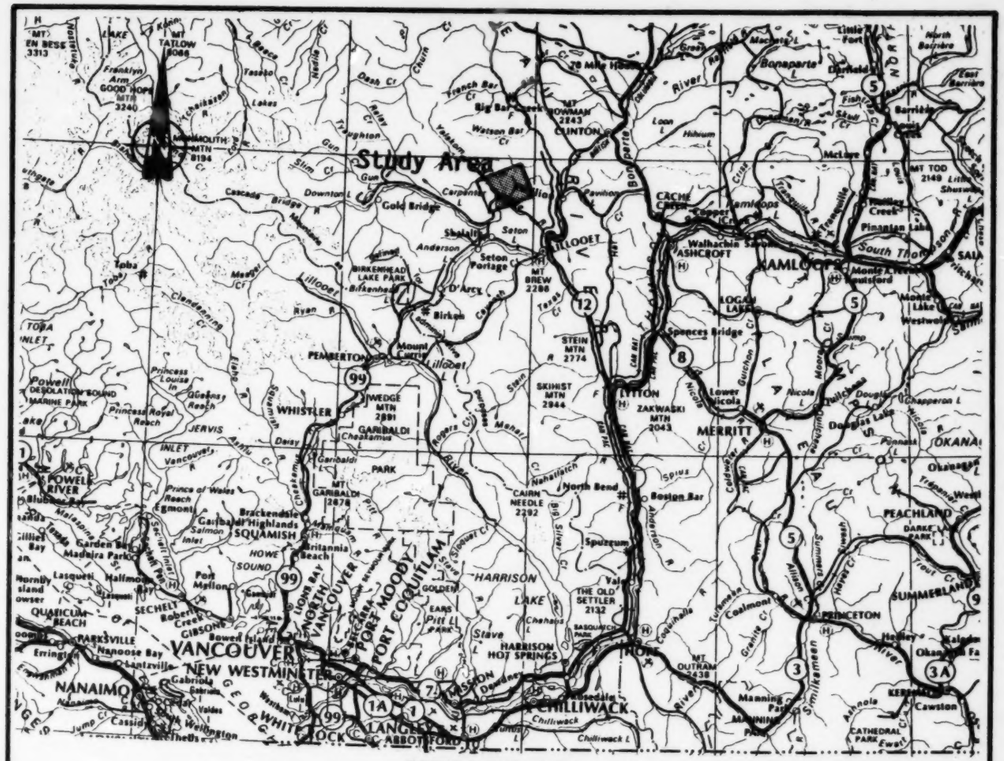
#	NO.	REVISIONS	
	1	Routes Updated	

DESIGNED		SUBMITTED	
DRAWN	KB	INSPECTED	
CHECKED DRAFTING		INSPECTED	
CHECKED DESIGN		INSPECTED	
APPROVED			
FUNCTIONAL CODE 2.1		DATE 03-09-14	SCALE 1:50000


Study Area
N
Illecillewaet
Mt Sir Donald 3284
Mt Bowman 2743
Clinton
Big Bar Creek
Watson Bar
Lillooet
Seton Portage
Anderson L
Seton L
Mt Brew 2286
Gold Bridge
Carpenter L
Cache Creek
Kamloops
Ashcroft
Walhachin
Savona
Pinantan Lake
Mt Tod 2149
Monte Creek
Westwold
Logan Lake
Spences Bridge
Stein Mtn 2774
Skihist Mtn 2985
Lytton
Zakwaski Mtn 2042
Merritt
Douglas Lake
Okanagan L
Peachland
Summerland
Princeton
Hedley
Keremeos
Cawston
Cathedral Park
Whistler
Wedge Mtn 2891
Garibaldi
Mt Garibaldi 2678
Garibaldi Highlands
Squamish
Britannia Beach
Howe Sound
Port Mellon
Gibsons
Sechelt
Roberts Creek
Pender Harbour
Egmont
Jervis Inlet
Princess Louisa Inn
Princess Royal Reach
Powell River
Lasqueti Island
Texada Island
Quadra Island
Cairn Needle 2292
North Bend
Boston Bar
Spuzzum
Yale
The Old Settler 2132
Harrison Lake
Harrison Hot Springs
Golden Ears Pitt Lk Park
Stave L
Chehalis
Mt Outram 2438
Manning Park
Chilliwack
Chilliwack L
Vancouver
North Vancouver
West Vancouver
Port Moody
Coquitlam
New Westminster
Burnaby
Richmond
Tsawwassen
White Rock
Langley
Abbotsford
Nanaimo
Parksville
Qualicum Beach
Ladysmith
Hanoose Bay
Saltzville
Gabriola
Cedar
Jump Cr
Cassidy
Ferrington
Lantzville
Departure Bay
Gabriola Passage
Strait of Georgia
Fraser River
Lions Bay
Howe Sound
Brackendale
Garden Bay
Madeira Park
Lasqueti
Hallmoon
Bowen Island
Sechelt
Roberts Creek
Gibsons
Port Mellon
Egmont
Jervis Inlet
Princess Louisa Inn
Princess Royal Reach
Powell River
Toba Inlet
Lake Powell
Desolation Sound
Marine Park
Princess Louisa Inlet
Queens Reach
Prince of Wales Reach
Salmon Inlet
Inlet
Vancouver
Garibaldi Park
Daisy
Rogers Creek
Cheakamus
Green R
Soo R
Lillooet R
Stein R
Nicola
Lower Nicola
Douglas Lake
Okanagan L
Trepanier
Westbank
Peachland
Darke Park
Trout Cr
Summerland
Princeton
Allison
Coalmont
Tulameen
Granite Cr
Hedley
Kaleden
Okanagan Falls
Keremeos
Cawston
Cathedral Park
Similkameen
Manning Park
Mannings
Skagit
Ashnola
Chilliwack L
Chilliwack
Mt Outram 2438
Harrison Hot Springs
Harrison Lake
Golden Ears Pitt Lk Park
Stave L
Chehalis
Basquin Park
Yale
The Old Settler 2132
Spuzzum
Boston Bar
North Bend
Cairn Needle 2292
Tsawwassen
Richmond
Burnaby
Port Moody
Coquitlam


Creek
Creek
Creek





KEY PLAN

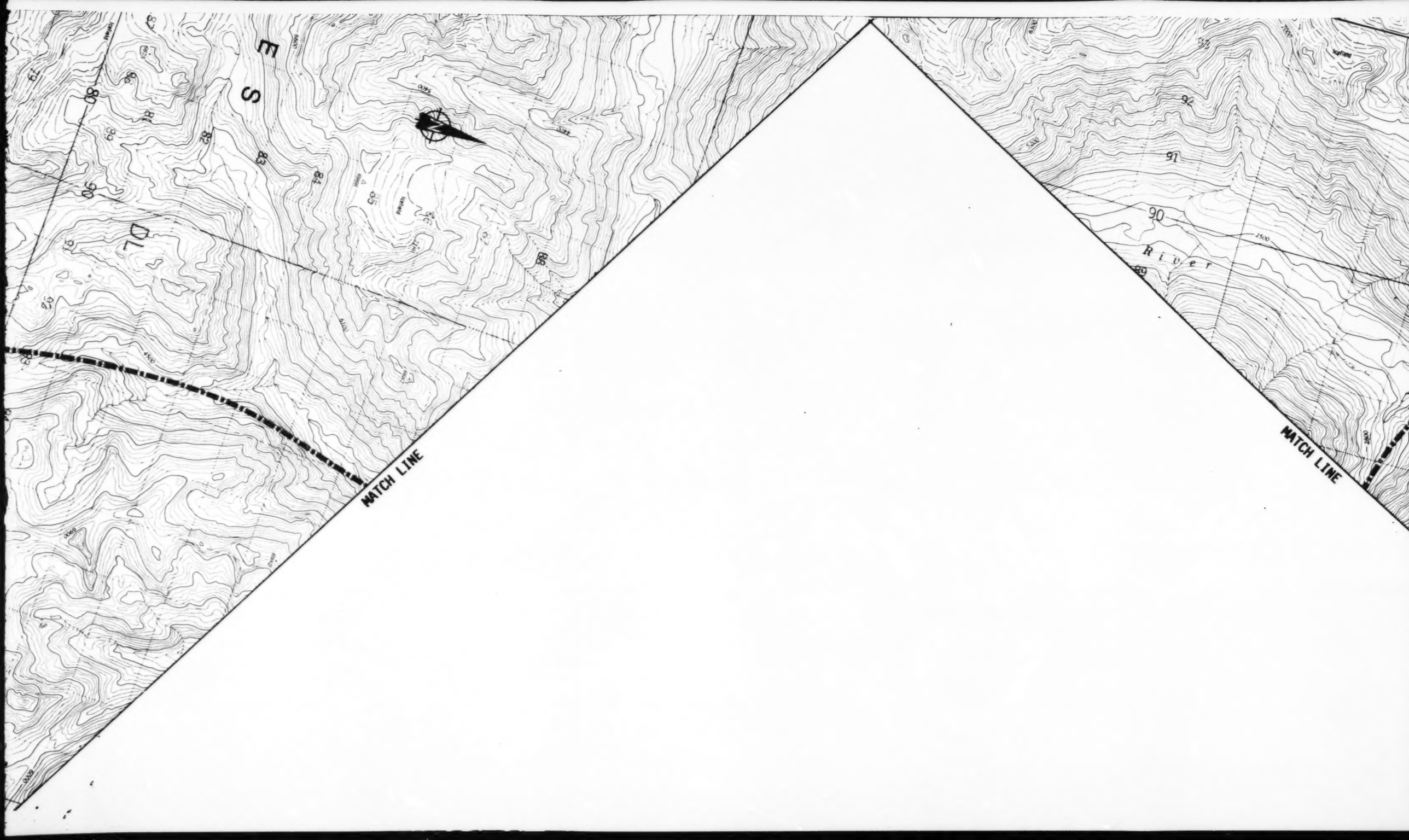
LEGEND

Route alternative 500kV T/L Circuit 5L46 on new R/W

µ	No.	REVISIONS	MADE	CHKD	SUBD	APPD	INSP	INSP	INSP	DATE

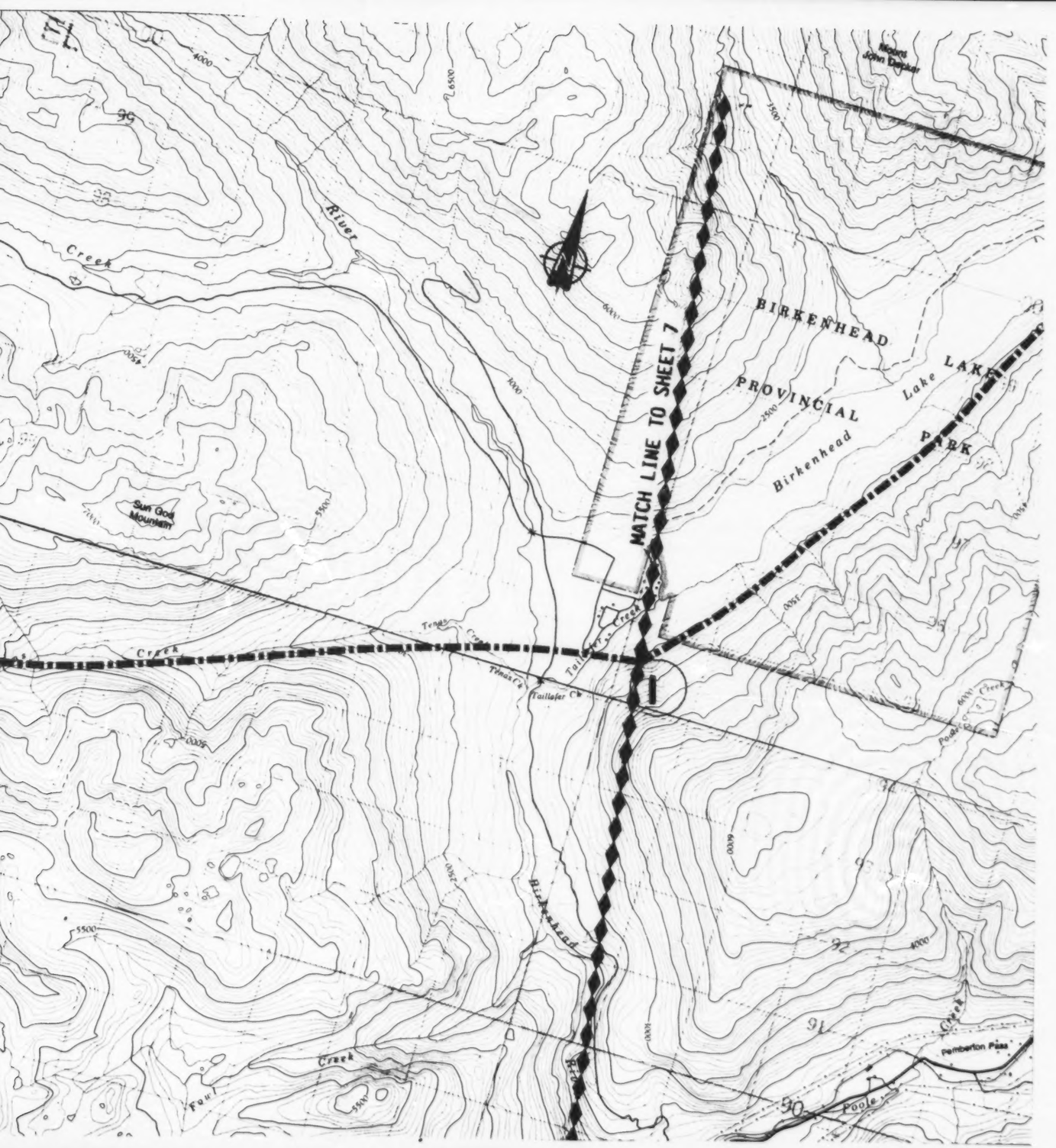
DESIGNED PJH	SUBMITTED	B.C. Hydro TRANSMISSION ENGINEERING DIVISION
DRAWN JBB	INSPECTED	KELLY LAKE-CHEEKYE 500kV TRANSMISSION LINE (CIRCUIT 5L46)
CHECKED DRAFTING PJH	INSPECTED	**PLAN OF ROUTE ALTERNATIVES**
CHECKED DESIGN	INSPECTED	ORE CREEK
APPROVED		
FUNCTIONAL CODE	DATE 90-11-16	SCALE 1:50000 DWG. No. 5L46 - T07 - X5M R

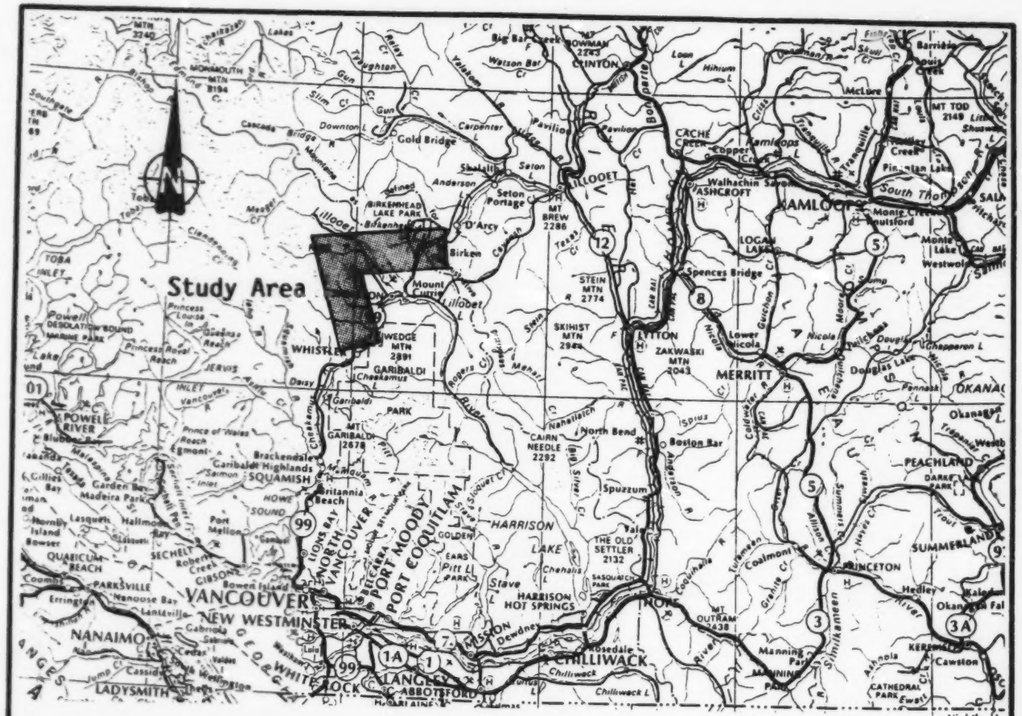
MATCH LINE TO SHEET 5


E S
D L
River
MATCH LINE
MATCH LINE

MATCH LINE

L 2637
L 1167
L 814
BK B
BK A
L 821
L 3112
TL 7674P
BK A
L 1172
L 1170
L 1173
TL 7674P
Mount Creek
PEMBERTON VALLEY
LILLOOET RIVER
Wolverine Creek
Thompson Cr
Johnny Sandy Ck
Gingerbread Creek
Gingerbread Ck
Gingerbread Lake
Mount Barbour
Copper Mountain
Forest Fire
Mount McLeod
Tenquille L
Tenquille
Bluecoat Glacier
Seven O'Clock Mountain
Opre Lake
Mount Ronayne
Pemberton Meadows
Wasp Creek
Wasp Flats
Ryan
PEMBERTON
Icefield
6603
6700
6400
6500
7000
7245
2500
2800
1500
1000
4500
6500
92





KEY PLAN

LEGEND

Route alternative 500kV T/L Circuit 5L46 on new R/W

No.	REVISIONS	MADE	CHKD	SUBD	APPD	INSP	INSP	INSP	DATE
2	Routes Updated	JBB	[illegible]						90-11-16
1	ROUTE REVISED	TEL	[illegible]						89-11-4

DESIGNED [illegible] SUBMITTED

DRAWN [illegible] INSPECTED

CHECKED DRAFTING INSPECTED

CHECKED DESIGN INSPECTED

APPROVED [illegible]

FUNCTIONAL CODE 2.1 DATE 89-09-14

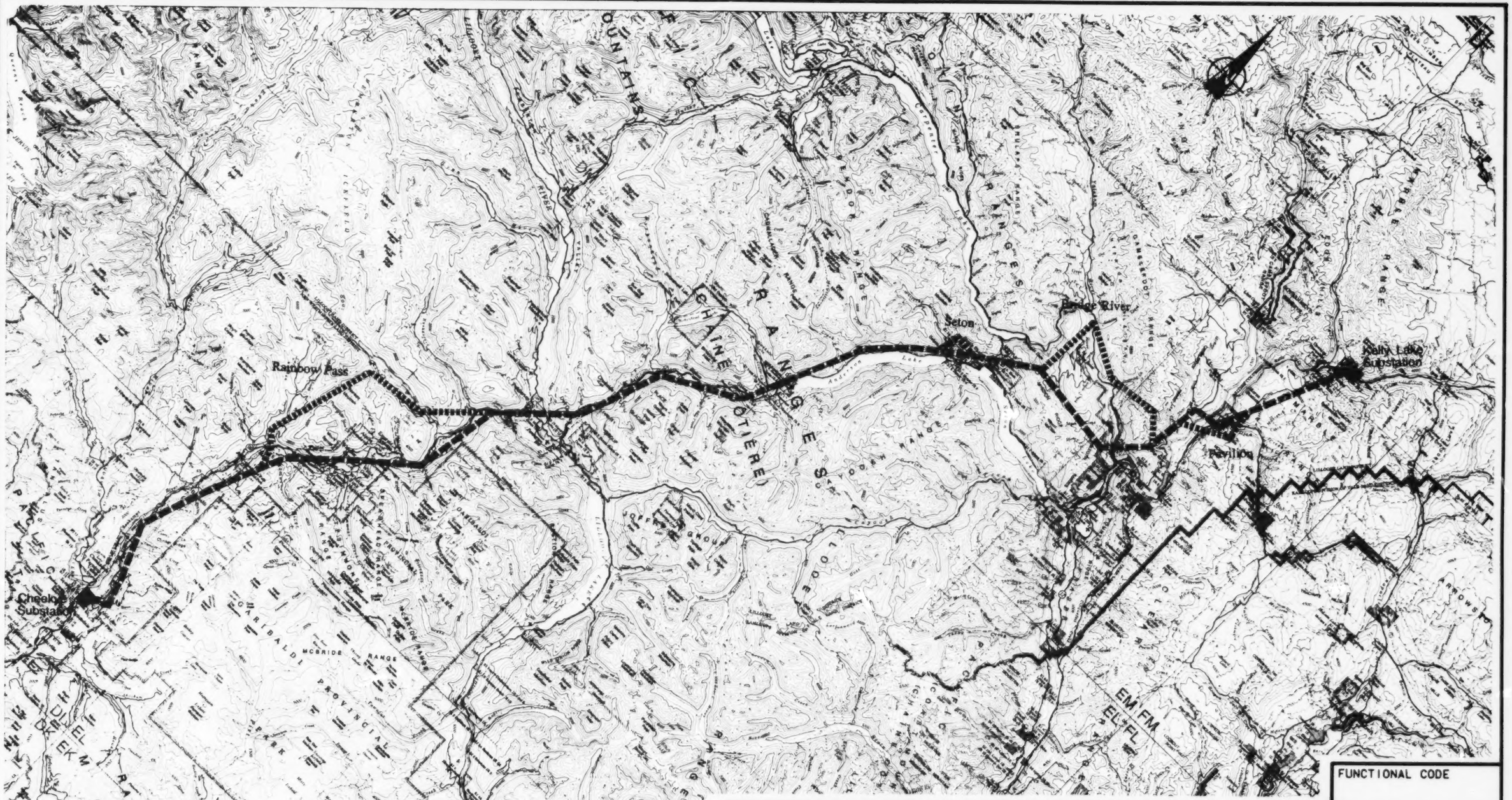
BC Hydro
TRANSMISSION ENGINEERING DIVISION

KELLY LAKE-CHEEKYE
500kV TRANSMISSION LINE (CIRCUIT 5L46)

PLAN OF ROUTE ALTERNATIVES

RYAN CREEK

SCALE 1:50000 DWG. No. 5L46-T07-X5M R2



Recommended Route

Alternate Route

DESIGNED	SUBMITTED
DRAWN	INSPECTED
CHECKED DRAFTING	INSPECTED
CHECKED DESIGN	INSPECTED
APPROVED	

SEAL

FUNCTIONAL CODE

B.C. Hydro
TRANSMISSION PROJECTS DIVISION

KELLY LAKE - CHEEKYE
500 kV TRANSMISSION LINE

Recommended Route

DATE DEC 90

SCALE 1:500,000

DWG. No **B-2**

μ	No	REVISIONS	MADE	CHKD	SUBD	APPD	INSP	INSP	INSP	DATE

CAD FILE No.